Report Prepared for the Research Division
Royal Commission on National Passenger Transportation

An International Comparison of the Economic Efficiency of Passenger Railway Systems

Tae Hoon Oum and Chunyan Yu
December 1991

RR-08

Opinions expressed are those of the authors and not necessarily those of the Royal Commission on National Passenger Transportation.

Report Prepared for the Research Division
Royal Commission on National Passenger Transportation

An International Comparison of the Economic Efficiency of Passenger Railway Systems

Tae Hoon Oum and Chunyan Yu
December 1991

RR-08

Cat. No. Z1-1989/1-41-8E
ISBN 0-662-19881-6

An International Comparison of the Economic Efficiency of Passenger Railway Systems

Final Report Submitted to

The Royal Commission on National Passenger Transportation

by

Tae Hoon Oum
and
Chunyan Yu

Faculty of Commerce and
Business Administration
University of British Columbia
Vancouver, B.C., V6T 1Z2, Canada
Phone: 1-604-822-8320
Fax: 1-604-822-8521

December, 1991

* The authors would like to acknowledge constructive comments received from David W. Gillen and Christopher Nash. They also acknowledge greatfully the detailed comments made by Mr. Roger Paquette of VIA Rail Canada which were valuable for revising our report.

Summary

An International Comparison of the Economic Efficiency of Passenger Railway Systems

by

Tae H. Oum and Chunyan Yu

Faculty of Commerce and
Business Administration
University of British Columbia
Vancouver, B.C., V6T 1Z2, Canada
Phone: 1-604-822-8320
Fax: 1-604-822-8521

The paper examines and compares the economic efficiency of railways in twenty one selected countries for which relatively consistent data are available. In particular, we calculated labour, capital and energy productivity measures, the gross measure of the DEA (Data Envelopment Analysis) efficiency index, and a net measure of managerial efficiency index.

The partial productivity measures and gross DEA efficiency ratings are analyzed using economic procedures in order to accomplish two major tasks: (a) to identify the effects of the controllable and uncontrollable variables on the partial productivity measures and the gross measure of the DEA efficiency index; and (b) to compute the net efficiency index after controlling for the effects of the variables which are beyond managerial control. An estimation of a production function provides an alternative technique to examine the effects of the controllable and uncontrollable variables on the efficiency performance of the passenger rail systems. Both methods gave essentially the same results.

The annual data for the sample railways for the 1978-1988 period are used as the sample data. These data are compiled from the annual reports of the railways, government statistical publications, and the international railways statistics. The empirical results are summarized below:

(a) Japanese National Railways (JNR), Korean National Railways (KNR), Portuguese Railways (CP) and Spanish Railways (RENFE) are the top performers in productivity and efficiency in 1988. This finding is true both before and after controlling for the effects of the variables beyond managerial control. Netherlands Railways (NS), Swiss Federal Railways (CFF) and French National Railways (SNCF) are also in the top performance category in terms of partial productivities and the gross DEA efficiency index. However, after controlling for the effects of the variables beyond managerial control, these firms rank somewhat below the top performers.

(b) JNR, Amtrak, British Railways (BR) and Danish State Railways (DSB) have improved productive efficiency significantly during the 1978-1988 period in virtually all criteria.

(c) Australian National Railways (AN), German Federal Railways (DB), Norwegian State Railways (NSB), Austrian Federal Railways (ÖBB), Belgium National Railways (SNCB), Hellenic Railways (CH), and Luxembourg National Railway (CFL) are the inefficient performers in virtually all criteria, i.e. partial productivities and gross and net efficiency indices.

(d) Our analysis of the gross DEA efficiency index and partial productivities as well as the estimated production function indicate that the efficiency performance of the passenger rail systems is significantly enhanced by an institutional and regulatory framework which gives greater freedom for managerial decision making.

(e) There is fairly convincing evidence to support the establishment of a single national passenger-only corporation like VIA Rail Canada and Amtrak.

(f) An increase in subsidy (ratio of subsidy to total operating cost) lowers the efficiency of the passenger rail operation.

In view of the above findings, we conclude that freedom of managerial decision making is an important element for improving the efficiency of a passenger rail system. Therefore, the institutional and regulatory framework for passenger systems must address this question squarely. A high level of government subsidy without setting an explicit cost recovery target will tend to reduce the level of net (residual) efficiency. By and large, the above conclusions and the empirical results of this study are consistent with those of previous European studies such as Nash (1991), Perelman and Pestieau (1988), and Compagnie, Gathon and Pestieau (1991).

VIA Rail's (gross) efficiency in 1988 was 30% lower than that of Amtrak. However, after controlling for the differences in traffic density, average passenger trip length, the percentage of electrified routes, and the level of government subsidy, the difference in the net efficiency between Amtrak and VIA Rail is reduced to about 10%. The differences in VIA

Rail's operating environment and the government policy towards VIA Rail (which tends to be politically motivated, and is beyond managerial control) is to blame for about two thirds of the difference in the gross efficiency level between Amtrak and VIA Rail. However, it is important to point out that neither VIA Rail's gross efficiency nor the net efficiency improved during the 1980-88 period while, during the same period, Amtrak improved gross and net efficiency by about 25% and 15%, respectively. In short, while VIA Rail's managerial efficiency should be improved, the federal government must give substantial autonomy (along with accountability for results) to VIA Rail management for making important strategic and market decisions. This will have a significant positive effect in improving VIA Rail's efficiency.

Our empirical results indicate that (a) the creation of a single nation-wide passenger rail corporation (VIA Rail Canada) was a positive step for improving efficiency; (b) the federal government's tight control on VIA Rail's strategic direction, market (particularly the exit control) and pricing decisions have adversely affected VIA Rail's productivity performance; and (c) financing the deficit through subsidy without setting explicitly the targets for cost recovery, productivity enhancement and service quality improvement have also adversely affected VIA Rail's productivity. Although our analysis did not include the issue of public disclosure of cost and performance indicators for VIA Rail, the analysts who looked into the question in the past agree that the protection of cost and input data (particularly the transactions between VIA Rail and the two transcontinental freight railroads) from public scrutiny discourages and perhaps prevents independent analysis of VIA Rail's performance from being undertaken.

Our recommendation is simple and clear. VIA Rail management should be given more autonomy in making strategic decisions of the corporation, choice of markets, and pricing decisions. The government in collaboration with management should set the targets for cost recovery, productivity and service quality. The cost recovery target should reflect the best effort productivity improvement factors. Where it is necessary to keep passenger rail services for social reasons, the government must compensate VIA through explicit social contracts similar to the practices in some European countries. VIA Rail should be given equal status to negotiate fees for the services provided by the freight railroads and for the use of rail infrastructure. Information on the costs and inputs, and some essential information on the transactions between VIA Rail and the freight railroads must be made public in order to make the performance transparent and to enforce management's accountability.

TABLE OF CONTENTS

An International Comparison of Economic Efficiency of Passenger Railway System

I. Introduction

In recent years, the financial and economic performance of the passenger rail system has attracted much attention primarily because of the mounting public subsidies and alleged inefficiency imbedded in the system. Since the early 1970's, many countries including Canada, the United States, Japan, Britain and France have introduced major policy changes in their passenger rail systems. For example, Canada, U.K, and France each set up a government-owned corporation to provide nation-wide services while the United States created Amtrak via a Congressional Act as a quasi-public enterprise in 1970. Japan broke up the Japan National Railway (JNR) system into six regional passenger corporations and one freight firm (JR group, still owned by the central government with a future plan to privatize). In Australia, rail passenger services are provided by five separate companies, all of which are government-owned. German Bundesbahn, a publicly-owned enterprise, operates within the Federal Ministry of Transport.

It is believed that the economic efficiency of passenger railway systems is heavily influenced by policy choices such as the regulatory, institutional and ownership arrangements of the industry, the relationship between freight and passenger railway systems, and the extent and methods of subsidization and/or taxation. The systems are also influenced by the external operating environments which are largely beyond managerial control, such as the spatial distribution of population and economic activities, the climate and topography of the nation, the extent of development of other passenger transport modes, the economic situation of the nation,

etc. Therefore, it is particularly interesting to observe that countries adopted fairly different approaches to resolve essentially the same problem: i.e., provision of required railway services with maximum efficiency. These differences in policy adopted by different countries provide an excellent opportunity to investigate the effects of the policy choices on the economic efficiency of the industry.

The objective of this report is to analyze the effects of various policy choices on the economic efficiency of the passenger rail system. In order to achieve this objective, this report first measures and compares economic efficiency of the passenger rail systems across selected countries. These results are further analyzed through econometric investigation in order to identify the effects of different policy choices on the economic efficiency of the system. Since passenger carriers also provide freight services in all countries other than Canada, the United States, and Japan, our study is likely to involve efficiency in freight operations to some minor extent.

In Section II, a brief review of the literature on efficiency of passenger rail systems is given. The literature review will focus on an international comparison of the efficiency of passenger rail systems. Section III discusses methods for making efficiency measurements and comparisons. In Section IV, we present the sample firms included in our analysis and their characteristics. Section V reports on the development of the data base. The railways' efficiency performance is measured and compared in Section VI. The effects of policy choices are analyzed in Section VII. The summary and concluding remarks are given in the final section.

II. Literature on Passenger Rail Efficiency

A number of studies have compared rail systems across different countries. Some of the studies are intended to provide an overall description of the institutional and financial framework of selected railway systems, and general indicators of railway performance. The studies by the Bureau of Transport and Communications Economics of Australia (BTCE, 1988) and VIA Rail Canada (1989) are such examples. While VIA Rail's study focused on rail passenger services, BTCE's study considered both passenger and freight services.

A second category of studies examine and discuss various issues related to government policy through the analysis of some basic performance indicators. Nash (1981) sought to discover how far the differences in the performance of Western European railways, in terms of market share, traffic trends and support requirements, may be accounted for by government policies. His study found that, in the passenger sector, the prices charged and the mix of services operated were very influential in determining both market share and support requirements, and that these decisions were almost entirely conditioned by government policy. Nash (1991) discusses in detail the key elements of the 1989 rail policy proposals by the European Commission regarding financial autonomy and contracts and the separation of the provision of infrastructure from carrier operations. To provide background for such discussion, the paper examined the economic characteristics of rail transport, and the methods of controlling and regulating rail transport in the member countries of the European Community. Schwier, Jones and Pignal (1990) compared the performance and policy environments of regional rail passenger services operated by VIA Rail, British Railways (BR), French National Railways (SNCF) and Amtrak, with respect to the organization, level, and utilization of services and the railways' financial performance.

A third category of study compares the performance of the railways using some simple productivity measures such as labour, fuel, and rolling stock productivities. Nash (1985) presented some labour productivity comparisons using train kilometres as a measure of output, and examined commercial performance, in terms of market share, of both passenger and freight services as well as the general financial performance of the railways. Thompson, Wood and Lures (1991) presented various measures of productivity for about 70 railways around the world, and discussed how productivity is affected by the relative size of the passenger services in a railway's operation. "Traffic units", which equal the simple sum of passenger kilometres and freight tonne kilometres, were used as the measure of output. Both studies discussed the problems in measuring inputs and outputs for comparing the performance of rail systems across countries.

The final category of study involved constructing a production frontier (and/or a cost frontier) either by parametric methods or by non-parametric methods. This frontier analysis allows measurement of the relative efficiency among production units in the sample. Thuong (1981) estimated the relative operational efficiency indices of some twenty plus railways from the late 1950s to the mid-1970s. Operational efficiency was decomposed into its technical and cost components. Technical and cost efficiency indices were computed from the estimated production or cost frontier. Perelman and Pestieau (1988) estimated relative technical efficiency measures of 19 railways through the estimation of a translog production frontier, then derived net technical efficiency measures after correcting for the portion of inefficiency caused by exogenous factors using an OLS estimation of the "most appropriate specification" (loglinear). Deprins and Simar (1989) extended the deterministic production frontier model in order to control the effects of exogenous environmental factors (exogenous to the production process) on the

observed inefficiencies. Then the (residual) technical efficiencies of 19 railways over the 1970-83 period were further analyzed using an extended model. Gathon and Perelman (1990) adopted a parametric approach, based on an estimated factor requirements function with labour units as the dependent variable, to estimate the technical efficiency of labour for a panel of 19 European railways over the 1961-88 period. In Simar (1990), three different approaches, parametric, nonparametric and semi-parametric, were applied to a data set consisting of the 19 railways over the 1970-83 period to construct a production frontier. Efficiency measurements from the three methods were examined and compared. Compagnie, Gathon and Pestieau (1991) computed efficiency measures for 19 European railways for the 1961-88 period from an estimated translog production function. These efficiency measures were then decomposed into net (including managerial) efficiency and regulatory efficiency using an index of the regulatory and institutional autonomy of the railways.

Various output measures have been used in these studies, such as train-kilometres (Nash 1981, Deprins and Simar 1989, Gathon and Perelman 1990, etc.), traffic units[1] (Thompson, Wood and Lures 1991) and the sum of gross tonne-km (GTK) of both passenger and freight trains (Compagnie, Gathon and Pestieau,1991). Although these output measures are rather crude and can cause bias in the resulting efficiency index, they have been used mainly for two reasons: (a) the difficulty of using multiple measures of outputs in estimating production functions; and (b) the lack of consistent data on multiple measures of outputs. The use of a gross measure of output such as train kilometres and gross tonne-kilometres (GTK) may be justified when one is interested in measuring and comparing the managerial efficiency of railroads without investigating the effects of government policies on efficiency, considering that, at least in the

[1] total traffic units is the simple sum of passenger kilometres and freight ton kilometres.

passenger rail sector, the prices charged and the mix of services operated by a railway are conditioned by government policy. However, when a researcher is interested in studying the effects of government policy choices as well as managerial efficiency, it is better for the analyst to choose one or more revenue-generating outputs such as passenger kilometres, number of passenger handled, revenue-tonne-kms, etc. over measure of gross outputs. This is because the revenue outputs are the only components of the gross outputs valued by the users and the society.

Almost all of the studies in the final category considered four input factors: number of employees, physical account of rolling stock, energy consumption (either in BTU or in equivalent KWH), and length of the network. Length of the network does not necessarily reflect the true quantity of the railway capital input, since the condition of the ways and structures capital (not just the degree of electrification) varies greatly among the railways.

A majority of the analytical studies (the final category) estimated "net efficiency measures" after correcting for the effects of exogenous factors. The exogenous factors considered include: degree of electrification, network density, average length of passenger trip, and average length of haul of freight traffic, etc. The resulting "net efficiency measures" are not yet the true measure of efficiency for comparing performance across different railways since the railways are subject to different levels of government control. Although the most recent studies (Gathon and Perelman (1990) and Compagnie, Gathon and Pestieau (1991) introduced an index of regulatory and institutional autonomy of the railways to correct for the portion of inefficiency caused by a lack of managerial freedom, there was no explicit analysis of the effects of government rail policy on the efficiency of the railways.

III. Methodology

Techniques for measuring efficiency can be classified into two categories: non-parametric methods which do not require econometric estimation of cost or production function; and parametric methods which require econometric estimation. Computation of total and partial factor productivity is the most common non-parametric method. However, this distinction between parametric and non-parametric methods is rather arbitrary because, in all cases, some statistical work is essential if one wants to investigate the causes of the changes in economic efficiency.

3.1 Non-Parametric Methods

With the non-parametric methods, first the efficiency of each passenger rail system is measured; next, these efficiency measures are analyzed to identify the effects of various controllable and uncontrollable variables on efficiency. This two-step procedure permits us to identify the effects of government policy and institutional choices, and allows us to make meaningful comparisons of the residual (managerial) efficiency across firms and over time after controlling for the differences in government policies and uncontrollable variables such as population density, topography, climate, etc.

Two non-parametric methods are used in this study: (a) computation of partial measures of productivities; (b) data envelopment analysis (DEA).

3.1.1 Partial Measures of Productivities

The partial measures of productivities are simply the ratios of passenger service output, passenger kilometres, to one particular input.

Three partial productivities are computed in this study: labour, capital and energy. Labour productivity is measured by the ratio of passenger kilometres to the number of "passenger" employees. Capital productivity is measured by the ratio of passenger kilometres to the number of passenger cars. Energy productivity is measured as the passenger kilometres per million BTU.

These partial measures of productivities are analyzed to identify, through econometric estimation, the effects of various controllable and uncontrollable variables.

3.1.2 Data Envelopment Analysis (DEA) Method

The Data Envelopment Analysis (DEA) method is used to measure overall efficiency of the passenger rail systems. It was first developed by Charnes, Cooper and Rhodes (1978) as a new technique in operations research for measuring and comparing the relative efficiency (either technical or managerial) of a set of decision making units (DMU) by using data on their past performance. It is a nonparametric method which allows multiple inputs and multiple outputs, and does not require strong a priori assumptions regarding the production technology or error structure. It yields a relative efficiency index for each observation in the sample through the solution of a constrained optimization problem.

DEA measures efficiency by estimating an empirical production frontier, that is, fitting pieces of hyperplanes to envelope the observed input-output data. The resulting piecewise linear production frontier is more flexible in approximating the true production frontier than is the so-called flexible translog parametric functional form (Banker, Charnes, Cooper and Maindiratta 1988). The inefficiency of a DMU is measured by the distance from the point representing its input and output values to the corresponding reference point on the production frontier.

3.1.2.1 Computation of DEA Index

Charnes, Cooper and Rhodes (1978) define the DEA efficiency measure (the CCR ratio) as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less than or equal to unity. In mathematical form:

$$
\begin{aligned}
&Max\ h_0 = \frac{\sum_{r=1}^{s} u_r Y_{r0}}{\sum_{i=1}^{m} v_i X_{i0}} \\
&st. \quad \frac{\sum_{r=1}^{s} u_r Y_{rj}}{\sum_{i=1}^{m} v_i X_{ij}} \leq 1 \qquad j=1,2 \ldots n \\
&\qquad u_r, v_i > 0 \quad r=1,\ldots,s;\ i=1,\ldots,m
\end{aligned}
\tag{1}
$$

where the Y_{rj}, X_{ij} are the known outputs and inputs of the jth DMU, the u_r, v_i are the weights (virtual multipliers) to be determined by the solution of the problem. $h^*_k = 1$ if and only if DMU_k is efficient relative to the other DMUs.

DEA can be viewed as an extension of simple-ratio analysis. In the simplest case, involving a single input and a single output, the objective function degenerates into a simple ratio. The reference set (e.g. the set consisting of the DMUs on the production frontier) becomes the DMU that is maximum on that ratio; efficiency is then calculated by comparing the ratio of each DMU against the maximum. DEA can also be viewed as a generalization of "total factor productivity". It is as if each unit were allowed to select the set of weights on its inputs and outputs that present that unit in its best possible light, subject to the condition that the set of weights selected does not give any other DMU a ratio greater than unity. A DMU that is superior to all others on any single ratio will therefore be rated as efficient. By assigning very high weights to the appropriate variables and very low weights to all other variables, the optimization will emphasize the ratio on which this DMU excels.

Note that the above ratio form of the model is a fractional programming problem. However, since $\Sigma^{m}_{i=1} v_i X_{ij} > 0$, if we let $\Sigma^{m}_{i=1} v_i X_{i0} = 1$, the problem could be replaced by the following linear programming problem[2]:

$$\begin{aligned} & Max\ h_0^{\prime} = \sum_{r=1}^{s} u_r Y_{r0} \\ & st. \quad \sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \leq 0 \qquad j=1,\ldots,n \\ & \qquad \sum_{i=1}^{m} v_i X_{i0} = 1 \\ & \qquad u_r,\ v_i > 0 \quad r=1,\ldots,s;\ \ i=1,\ldots,m \end{aligned} \tag{2}$$

and hence solutions can be obtained by repeated use of linear programming software.

[2] The model used here is the one initially proposed by Charnes, Cooper and Rhodes (1978) which points out differences among DMUs in the most critical way. It assumes constant returns to scale. A variant of DEA (Banker, Charnes and Cooper, 1984) provides for partial control of the economies of scale effect across comparison DMUs.

3.1.2.2 Identifying Effects of the Policy Variables on the DEA Index

The DEA Efficiency measures are considered as "gross (or observed) efficiency indices". These indices are influenced by the differences in the railways' operating environments (such as network and market size, traffic density, climate, topography, economic situation of the country, etc.) and the regulatory and institutional arrangements. The "true (net) efficiency" of the passenger rail systems can be measured and compared after controlling for effects of these controllable and uncontrollable variables.

In order to identify the impacts of policy and uncontrollable variables on the DEA efficiency index, and to measure the "true (net) efficiency" of the railways, the DEA indices (h^*_k in equation (1) and (2)) are regressed on a number of explanatory variables. However, there is a methodological problem associated with such a regression. As defined in (1) and (2), the DEA index falls between 0 and 1 ($0 < h^*_k \leq 1$), making it a limited dependent variable. Consequently, an OLS regression of h^*_k would produce biased parameter estimates. In order to treat the limited dependent variable properly, therefore, we choose to use the following form of Tobit model (Tobin, 1958, Amemiya, 1985):

$$\begin{aligned} Lh_k &= Z_k'\beta_k + \eta_k \quad & \text{if } Lh_k < 0, \quad k=1,\ldots,n \\ &= 0 & \text{otherwise} \end{aligned} \tag{3}$$

where Lh_k is the logarithm of the DEA efficiency index, Z_k is a vector of the logarithms of the factors potentially influencing rail efficiency, β is a vector of coefficients to be estimated, and $\{ \eta_k \}$ are assumed to be independently identically distributed errors.

This analysis accomplishes two tasks. First, it identifies effects of the controllable and uncontrollable variables on the gross DEA efficiency index. Second, it allows one to compute the true (net) efficiency index from the residuals of the Tobit regression.

3.2 Parametric Methods

With parametric methods, one can directly construct a best practice frontier taking into account the controllable and uncontrollable variables. The parametric method is used here as an alternative approach to DEA-TOBIT analysis to re-examine the results from DEA-TOBIT analysis. One widely used parametric method, the construction of a production frontier function, is adopted in this study.

A determinist loglinear production frontier function is estimated by the corrected ordinary least squares method (Greene 1980). That is, we first estimate the loglinear production function by OLS, then we correct the constant term by shifting it up until no residual is positive and one is zero. This provides a frontier with respect to which the efficiency of each DMU can be evaluated by measuring the relative distance between the frontier output and the actual output, given a certain level of input. The DMU which has the highest positive residual is by definition 100% efficient.

Let y_i be the output, measured by passenger kilometres, of the i^{th} DMU (observation); x_{ij} be the inputs variables; z_{ik} be the uncontrollable variables; v_{il} be the controllable variables which are in the form of dummy variables; and ε_i be the residual term. OLS estimation gives the following equation:

$$\ln y_i = a + \sum b_j \ln x_{ij} + \sum c_k \ln z_{ik} + \sum d_l v_{il} + \varepsilon_i \tag{4}$$

where a, b_j, c_k, and d_l are the regression coefficients. Let $E = \text{Max}(\varepsilon_i)$, one obtains the following frontier function:

$$\ln y_i^F = a + \sum b_j \ln x_{ij} + \sum c_k \ln z_{ik} + \sum d_l v_{il} + E \tag{5}$$

which allows for measuring the efficiency of the DMUs:

$$e_i = y_i / y_i^F = \exp(\varepsilon_i - E) \leq 1 \tag{6}$$

where e_i is the efficiency index, which takes into account the controllable and uncontrollable variables.

IV. Sample Firms and their Characteristics

An annual panel of 21 selected railways for the 1978-88 period forms the primary data base used in the present study. The railways are selected because their data are available in a relatively consistent form over the sample period. Our sample firms represent different institutional settings and operate in a variety of environments. The names of these railways and the years for which data are collected for this study are listed in Appendix I. Of our sample

railways, only German Federal Railways (DB), Italian State Railways (FS prior to 1985 only) and Danish State Railways (DSB prior to 1986) are run by governmental agencies while Amtrak (U.S.) and French National Railways (SNCF prior to 1982 only) are organized as quasi-public firms[3]. The rest of the railways are organized as public firms (Crown corporations).

With the exception of VIA Rail Canada, all of the railways own and operate at least some of the tracks on which they provide passenger services [4]. VIA Rail Canada and Amtrak provide only passenger services while other railways in the sample provide both passenger and freight services. Most of the railways receive payments from governments for specific services provided. Danish State Railways (DSB) and Norwegian State Railways (NSB) receive subsidies to cover 100 percent of their deficits (non-discriminating subsidization), and Japan National Railways (JNR prior to the breakup and reorganization in 1987) and German Federal Railways (DB) rely largely on debt financing to cover their deficits.

The management of some of the railways including Amtrak, British Rail (BR), and Netherlands Railways (NS) enjoy substantial freedom for making strategic and operational decisions without government intervention, provided that the predetermined minimum performance criteria are met. On the other hand, some of the railways such as the Finnish State

---

[3] Throughout this paper, the term "quasi-public firm" is used to indicate mixed ownership by public and private interests.

[4] Amtrak also relies on the track and facilities of private freight railroads for its operation other than in the Northeast Corridor in which it owns its own roadbeds. The traffic in the Northeast Corridor accounts for over 50% of Amtrak's total volume.

Railways (VR), Austrian Federal Railways (ÖBB), Norwegian State Railways (NSB) and VIA Rail Canada are subject to strict governmental control[5].

There are large variations in operating environments across the selected railways. GDP per capita and population density in Table 1 and Table 2 provide some background information on the countries in which the railways operate. Table 3 compares rail's share of the total passenger traffic (in terms of passenger kilometres) across different countries. In Japan, railways are important players in the passenger transportation market; the market share of the rail mode in passenger transportation was 37% in 1987. In contrast, Canada and the U.S.'s rail traffic represents a tiny portion of the total intercity passenger transport market (1.6% for Canada, and 0.7% for the U.S. in 1988).

Length of route (Table 4) is considered as an indicator of the size of the railways, which ranges from a 270 kilometre network of the Luxembourg Railway (CFL) to larger firms such as the French National Railway (SNCF) and Amtrak that serve rail lines of over 30,000 kilometres. Passenger traffic volume is measured by passenger kilometres (Table 5). JNR produces over 190 billion passenger kilometres each year while CFL and Australian National (AN) produce only a little over 200 million passenger kilometres. Table 6 compares the average trip length of rail passengers on those railways. VIA Rail Canada and Amtrak serve substantial amounts of long distance traffic while most other railways have a larger portion of their traffic in suburban and commuter services. Australian National Railways (AN) provide mainly freight services. Some railways, such as SNCF, Finnish Railways (VR) and Turkish Railways (TCDD), display a fair

---

[5]While recently VIA Rail Canada was given substantial autonomous decision making power (such as choosing which markets to serve) by the National Transportation Agency of Canada, VIA's autonomy is still tightly controlled by the contractual arrangements with the federal government (Transport Canada).

balance between passenger and freight services as shown by the comparison of passenger train kilometres and freight train kilometres (Table 7). Other railways, such as NS and Danish Railways (DSB) provide mainly passenger services and, at the extreme, VIA Rail and Amtrak provide ONLY passenger services. The Swiss rail network is fully electrified (Table 8) while some railways still operate over their entire network with fuel traction only, such as Hellenic Railways (CH) and VIA Rail. Below, some of the sample railways are briefly described.

1. AMTRAK - The National Railroad Passenger Corporation (US)

Amtrak is a quasi-public enterprise with the Federal government as the preferred shareholder and common shares owned by a consortium of the U.S. class I railways. It is responsible for the provision of nationwide passenger railroad services. Amtrak operates over 24,000 miles of rail line providing services in every state but five in the continental United States. It owns 621 miles of rights of way, mainly the Northeast Corridor between Washington and Boston. Other than in the Northeast Corridor (which accommodates more than 50 percent of its total traffic), Amtrak relies on the use of the track and facilities of private freight-hauling railroads.

Although Amtrak is not an agency of the federal government[6], the federal government plays an important role in its operation. Among the nine members of its Board of directors, two are selected by the Department of Transportation, and five are named by the President of the United States[7].

---

[6] Amtrak employees are not part of the federal civil service system.

[7] Amtrak's president and the U.S. Secretary of Transportation are automatically on the Board.

Amtrak receives annual financial support from the federal government which comes in the form of grants from the Secretary of Transportation as directed in appropriation bills passed by Congress. Congress usually authorizes a ceiling for Amtrak funding over one or more years. The authorization bill must be passed by both the House and the Senate and signed into law by the President. The authorization bill may also contain changes in the Rail Passenger Service Act, the law that created Amtrak and sets the rules for its operation. The appropriation bill in which Congress appropriates funds for Amtrak must also be passed by both the House and the Senate, and be signed into law by the President.

Although Amtrak reports directly to Congress, it has freedom over decisions regarding fare and service levels, provided the minimum performance criteria set in the Amtrak Improvement Acts (which include specific financial targets) are met. The Rail Passenger Service Act allows Amtrak to operate services with financial support from states (or, regional or local agencies) providing certain standards are met. Amtrak provides both intercity and commuter services. It faces competition from deregulated airline and bus services.

2. British Rail - UK

British Rail (BR) is operated by the British Railways Board (BRB). Members of the BRB are appointed by the Secretary of State for Transport. The Board is required by law to provide railway services in Great Britain with due regard to efficiency, economy and safety of operation. BRB controls most of the railway network in Great Britain. BR operates over more than 16,000 kilometres of rail line, providing both passenger and freight services.

The government, through the Secretary of State for Transport, periodically sets out in detail the objectives the government wishes BRB to pursue as well as policy guidelines. BRB is responsible for policies to meet the government's objectives. The Board also has a duty to furnish the Secretary with such information as he/she may reasonably require. The Board is not subject to statutory control regarding fares and charges, though in setting the financial objectives the Secretary may give some guidance on fares. Day-to-day management is the responsibility of five business sector directors[8] and six regional general managers. Major investment plans require approval from the government.

BR's passenger network is comprised of a fast-Intercity network linking the main centres of Great Britain, local stopping service (the Provincial), and commuter service in and around the larger conurbations, especially London and South-east England (the Network South-East). InterCity is considered to be providing commercially viable services[9] while the Provincial and Network South-East provide services which are considered to be socially required and which are unremunerative. These services are financially supported by the government through Public Service Obligation grants. These latter two services also receive financial support from a number of local transit authorities. BR has a responsibility to fund its own infrastructure expenditure for its commercial sector, while funding for infrastructure expenditure for the subsidized network is contained within the PSO grant.

---

[8] In 1982, BR introduced the sector management system. Under the sector system, BR's operation is divided into five sectors: freight, parcel, InterCity, Network Southeast and Provincial passenger services.

[9] InterCity became a fully commercial business in 1988 when it achieved an operating surplus.

The UK is effectively the only European country where the national railway network faces unrestricted express coach competition on domestic routes (since 1980) and, therefore, rail fares reflect market value rather than political control.

3. CFF-SBB - Swiss Federal Railways (Switzerland)

CFF-SBB is a state-owned railway. It operates over a network of 3,000 kilometres, providing both passenger and freight services. It provides mainly main line services, as many lightly used branch lines are separate organizations with a mixture of private[10] and local government ownership.

CFF-SBB is required by law to place profits (when available) in a reserve fund to be used to cover future deficits. The Act governing the Swiss Federal Railways also prevents deficits from being carried over. In the case of deficits that cannot be covered from the reserve fund, the Federal Assembly has to pronounce a ruling on the absorption of the deficits (by the government).

The Confederation participates in the financing of rail investment. The Confederation may grant either long-term loans or non-repayable loans to CFF-SBB. Furthermore, third parties (e.g., cantons or communes) with a commercial interest in a project, can be obliged to finance part of it. According to the law, the Confederation may use the yield from fuel taxes to finance various railway projects aimed at relieving road transport conditions.

---

[10]There are about 120 private companies controlling private railways, chiefly along short mountain routes, with a total length of 2,200 kilometres.

In 1987, the government took over financial responsibility for infrastructure, making CFF-SBB the first European railway with this structure. The government charges CFF-SBB a sum based on what the railway can afford. However CFF-SBB's commercial services (freight and long distance passenger) have to make a contribution towards infrastructure costs, which is fixed in advance.

4. Deutsche Bundesbahn (DB) - German Federal Railways (W. Germany)

DB is a publicly-owned enterprise operating within the Federal Ministry of Transport with its own accounting system. DB is run by a board of management appointed by the government. It operates over a network of about 27,000 kilometres, providing both passenger and freight services.

DB receives financial support from the Federal government on three main bases. They include compensation for mandatory social services (mainly local and suburban passenger operations[11]), social service supplements to employees, and investment support. In addition to government compensation, DB relies on debt to cover its remaining deficits. It also borrows money to make additional investments which are not funded by the government.[12]

DB enjoys a significant degree of protection by regulation from intermodal competition. A strict policy of control on private road passenger services has effectively excluded the development of a system of regular intercity bus services.

---

[11] InterCity service receives no compensation.

[12] DB has invested substantial amounts in track and rolling stock for fast Intercity connections.

DB has responded to competitive pressure (from automobiles and airlines) in the short term by concentrating on the development of InterCity as a network, with an hourly frequency on each of five trunk routes with closely scheduled interconnection at key stations. It is also making a major investment in a new high speed route (for mixed traffic). DB is considering transferring secondary lines to the private sector in order to concentrate on operating lines connecting major population centres.

5. FS - Italian Railways (Italy)

FS is an autonomous body which administers the State Railways. It is controlled by the Minister of Transport who is assisted by an administrative board. Prior to 1985, FS was an agency of the Ministry of Transport. The Minister of Transport was the Chairman of FS and Parliament ran FS through the Minister. In 1985, Parliament passed a law to make FS function as a commercial corporation subject to greater financial discipline, rather than as a division of the Ministry of Transport; however, the government has retained control of the domestic fares. FS operates over a network of 16,000 kilometres, providing both passenger and freight services. The government has provided FS with a significant amount of capital as well as operating funding over the years[13].

---

[13] FS is one of the most subsidized railways in the world.

FS is now one of the most extensive passenger rail networks in the world. However, given the existence of a good motorway network and the low speed[14] of its standard InterCity service, FS would find great difficulty in competing effectively if it were to operate in a highly competitive environment. At the present time, second class fares are very low and there is no competing express coach network, hence passenger volume is high.

In 1988, commuter traffic accounted for 17% of passenger-kilometres, but generated scarcely 0.5% of earned income, due to the low fares paid by commuters. An act of the parliament was passed in 1988 which enabled FS to increase fares by up to 20% a year until they reach the western European level.

Apart from the State Railways which operate the majority of Italian rail lines, there are 27 local and municipal railway companies.

6. JNR - Japanese National Railways (Japan)

JNR was established as a public corporation in 1949 under the strict control of the Ministry of Transport and the Diet (Japanese Parliament). It operates over a network of about 21,000 kilometres (mainly narrow gauge lines), providing both passenger and freight services.

Major decisions, including the setting of freight rates and passenger fares, required permission from the Minister. The Diet had the right to approve the annual budget of JNR, and it had to approve changes in rates and fares above certain legally prescribed levels as well as

[14] The topography may not permit any real savings through the adoption of a dedicated high speed passenger line.

matters relating to personnel and investment programs. Besides the government's involvement in JNR's operation, JNR also had serious labour relations problems due to overstaffing and heavy pension liabilities.

At the end of the sixties, the government started to grant financial support to JNR which covered only a part of its huge deficits[15]. The greater part of the losses were covered by loans which accumulated an enormous interest burden in later years. In 1987, JNR was restructured into six regional passenger companies and one freight company, the Japan Railways Group (JR). The new JR network was to consist of independent private companies. Although they are in the form of joint-stock companies, all shares are for the moment owned by the government. They are to be sold to the public in the near future after the profitability of each company is confirmed.

JNR (JR) faces competition, to some degree, from private railways in addition to intermodal competition from automobiles and airlines.

7. NS - Netherlands Railways (Netherlands)

NS is a limited liability company in which the State is the sole shareholder. NS operates all railway lines (a network of about 2,800 kilometres) in Netherlands, providing mainly passenger services.

---

[15] Unlike other railways where freight services are considered more profitable, at JNR, passenger services are more profitable (at least less deficit-generating).

Service frequency is an important part of the social obligation established by government; a frequency (1, 2 or 4 trains per hour) is stipulated for each type of service. This results in higher train density (ie. train kilometres per route kilometre).

8. RENFE - National Systems of Spanish Railways (Spain)

RENFE is a body with independent legal status which behaves like a commercial undertaking. It is one of the three rail systems in Spain, RENFE, FEVE (Spanish Narrow Gauge Railways) and private companies[16]. RENFE operates over a network of about 12,500 kilometres, providing both passenger and freight services.

RENFE reports to the Ministry of Transport and Communications, and its director is appointed by the Government. The Minister has statutory powers to approve budgets, plans and investment programs, annual reports and accounts, overall price increases, and rail line closures, and to set the level of state support for the railways. The power of the government is represented by ministerial delegates to the RENFE board, one for the treasury and one for the Ministry of Transport. The operation of RENFE is based on a programme-contract between RENFE and the Government. The programme-contract covers the RENFE objectives on a wide range of physical and quality of service indicators, and consists of a set of mutual commitments tied to certain financial and operating goals for RENFE. The programme-contract defines the PSO payments to RENFE and sets RENFE a set of financial objectives. RENFE's operating and capital budget, and fare structure are subject to government control under the programme.

[16] There are some rail systems operating local short lines and suburban services.

RENFE is to implement a major reorganization designed to provide the railway with a more flexible and decentralized management structure allowing a more rapid response to the changing market. The new structure consists of three groups: one comprises six commercial management units (4 passenger and 2 freight), each unit is responsible for marketing its services; another group includes management units responsible for motive power and rolling stock, these units sell their service to the commercial units and potentially to third parties; the third group covers infrastructure maintenance and train operations. In addition, there is a small corporate structure responsible for such things as arranging financing, telecommunications and computer management control.

9. SJ - Swedish State Railways (Sweden)

SJ is a public commercial enterprise. It operates over a network of about 11,000 kilometres, providing both passenger and freight services.

Parliament and the Government decide the annual total amount of SJ investment. However, SJ is generally independent to make its investment decisions, as long as these are in line with the government's general transport policy. Parliament also decides the size of the railway network. SJ has (since 1985) the authority to make independent decision in all matters concerning organization, staff, passenger fares and freight rates. The investments were partly self-financed, partly financed by State budget provision for which SJ was obliged to pay interest.

The railway was divided into "Affärsbanenätet", a commercial network, and the "ersättningsberättigade" network, some lines of which remained for social (economic) reasons but were to be periodically examined with a view to possible discontinuation. If the central or a relevant local government requires the maintenance of commercially unviable services, it is required to buy a "collective ticket[17]" for this public good, leaving the balance of total cost and revenue to be made up from fares. The government had also to step in from time to time to restore SJ's financial position by debt remissions.

Since 1988, Sweden has physically separated responsibility for railway infrastructure from the provision of railway services. SJ is now a rail transport enterprise with the objective of running trains in the most business-like manner possible on the rail tracks of a rail authority (Banverket, BV). SJ (and other operators) pay the state (through Banverket, the administration responsible for the infrastructure) a track fee and fixed charge costs based on a pre-determined formula for use of the infrastructure. The state provides the money for maintenance of the infrastructure and new investment, and it pays that to BV. The regions of Sweden are free to buy their local rail services "on the open market" by asking for offers from SJ and other operators. SJ is no longer under any obligation to pursue businesses which it finds commercially unattractive. There are a few remaining commercially unviable interregional lines which are considered to be essential for some regions, for tourism as well as defence. The central government will pay SJ what is required to maintain passenger services on these lines.

[17] SJ wanted to avoid the word "subsidy".

SJ is structured into four divisions: passenger, freight, vehicle maintenance, and plant and property. Each one is a profit centre, and passenger and freight divisions have to operate on market principles. The passenger division passed the breakeven point in 1989 and is now in the black (due to a small increase in traffic and some large increases in fares) for the first time in many years.

10. SNCF - French National Railway Company (France)

SNCF is a commercial public corporation operating the French railway network (about 34,500 kilometres). SNCF was 51 percent state-owned until it was wholly nationalized in 1982. SNCF is divided into five systems which are further subdivided into 25 areas, all under the direction of a general headquarters in Paris. SNCF provides both passenger and freight services.

The government is involved in various aspects of SNCF's operation, including preparation of annual operating and capital budgets, setting of passenger fares and freight rates and decisions concerning the expansion of railways throughout France. Some of SNCF's capital investments are financed by the government. SNCF has also relied on loans for the construction of fixed installations[18]. The relationship between the government and SNCF is formalized through two operating documents. One document sets out a contractual relationship between government and local authorities and SNCF, and establishes the principles for community service obligations (CSO) and the government financial support. The other document determines the amount of compensation payments. The contracts assign SNCF a set of commercial, operational and financial targets to be achieved.

---

[18] The source of these loans have become diversified (low-interest or market rate, domestic or international).

SNCF now operates the fastest passenger train services in the world over the TGV-Atlantique system between Paris and Tours, completed in 1990. It is currently moving toward establishing a high speed network.

11. VIA Rail (Canada)

VIA Rail is a Crown corporation with the mission to manage and provide safe, efficient, effective and economic rail passenger services in Canada to meet the needs of the travelling public. It uses the roadway infrastructure of other railway companies which also assure the control of train operation. It has operating agreements with these railways, namely CNR and CPR, for use of their track facilities, train personnel and rollingstock servicing, etc. VIA operated over a network of 18,500 kilometres (in 1988[19]) in eight Canadian provinces. Apart from VIA's operation, there are also a few regional railways that provide limited passenger services which do not compete with VIA's services.

VIA receives funds from the Government of Canada in the form of contract revenues and financing for its capital expenditures. The contract revenues pertain to services, activities and other undertakings provided by the Corporation for the management and operation of railway passenger services in Canada[20]. The funding for capital expenditures is provided under the Financial Administration Act in accordance with terms and conditions approved by the Treasury Board. Recently, the Canadian government decided to reduce the total passenger subsidy to VIA Rail from the peak $637 million in 1988 to $250 million per year by 1992.

---

[19] VIA's service was cut almost by half in 1990 by the government in its effort to control VIA's mounting subsidies.

[20] Under an agreement with the Government of Canada.

Until recently, charges under the operating agreements with CNR and CPR were recorded on an incurred and estimated basis. These charges were subject to adjustment by the NTA (CTC prior to 1988) following a review of the actual costs incurred each year by the parties concerned. Because of the system of cost-plus ex post billing by railways, VIA had little control over a major portion of its costs[21]. VIA is responsible for route and service planning as well as pricing. However, the Minister of Transport has ultimate decision making authority through a budget approval mechanism. In a recent decision (decision No. 538-R-1990, dated Oct 29, 1990), the NTA reduced the regulatory regime to make it easier for VIA to respond to changes in the market. VIA faces limited competition from intercity bus operators who are also regulated monopolists. VIA's main competitors are deregulated airlines and automobiles.

V. Source of Data and Description of Variables

In this section, we describe the data and the sources of these data. The sample set used in this study consists of data for 21 railways. The names of the railways and the years for which data are collected are listed in Appendix I.

In order to achieve the objective of this report, that is "to analyze the effects of various policy choices on the economic efficiency of the passenger rail systems", we need to obtain two sets of data: (a) output and inputs, and (b) the variables describing the operating environment and production characteristics of the railways.

---

[21] Effective January 1989, VIA Rail entered into a ten-year operating agreement with CNR to cover services provided by the latter. Effective January 1990, VIA Rail entered into a two-year (renewable every year) operating agreement with CPR. Under these new agreements, 65% of the payments are negotiated in advance and guaranteed, and 35% of the payments are subject to satisfactory performance (given the predetermined minimum performance criteria). NTA plays a minor role under these new agreements; it will serve as an arbitrator in case of dispute.

5.1 Output and Input Variables

Passenger kilometres are considered the measure of passenger service output. Labour, energy consumption, rolling stock (number of passenger cars and number of passenger locomotives), and ways and structures are the four inputs considered.

5.1.1 Output

The output data, passenger kilometres, are readily available from **International Railways Statistics**[22] for the European Railways, JNR (Japan) and KNR (Korea), and from railway annual reports for VIA Rail Canada and Amtrak (US). AN (Australia) does not routinely report passenger kilometres. Therefore, passenger kilometres for AN are obtained from **YEAR BOOK Australia**[23] for 1979 - 1984, the data for 1985 - 1988 are estimated using the average passenger trip length in 1984.

5.1.2 Input

The input data, however, are not readily available except for the information on the number of passenger cars which is obtained from **International Railways Statistics** for the European railways, JNR and KNR, from railway annual reports for Amtrak and AN, and from Statistics Canada Catalogue 52-215, 52-216 for Via Rail Canada.

---

[22] Published by International Union of Railways, Paris, issues 1978 -1988.

[23] Australian Bureau of Statistics, Canberra, Australia

There are two problems associated with the measurements of labour, energy and passenger locomotive inputs in rail passenger services. The first problem is that although most of the railways provide both passenger and freight services, some of the inputs used in their operation are not directly assignable to either passenger services or freight services[24]. There is no well defined method by which to allocate those common and/or joint inputs between passenger and freight services. For this study, we only have data on the total inputs (labour, locomotive and energy) employed in the railways' operation. The second problem is the fact that VIA Rail and Amtrak use some personnel and trackage of the freight railroads, and thus the true inputs involved in their operation are not readily available. These problems forced us to estimate inputs attributable to rail passenger services. The following is a brief description of how those inputs are estimated.

(A) Labour

Although the number of labour hours is a better measure of labour input, in this study the number of employees is used because the statistics on labour hours are not available. The number of VIA Rail's employees is obtained from its annual reports (1980-1988). This number is adjusted upward by adding the number of employees of CNR and CPR (the freight railways who perform passenger services under contract with VIA Rail) attributable to VIA Rail's passenger operation. We first needed to estimate the number of employees of CNR and CPR working for passenger rail services to fulfil contracts with VIA Rail. This is done by assuming that the labour costs accounts for a fixed percentage of VIA's operating costs[25], then using CNR and

---

[24] The costs of using such inputs are referred to as common costs and joint costs.

[25] Cubukgil and Soberman (1984) estimated train crew costs at about 55 percent of the VIA Rail's train operation costs.

CPR's average labour compensation to compute the estimated number of labour inputs. We next allocate part of CNR and CPR's road maintenance personnel to VIA Rail's operation. This is done through a linear regression of the CNR and CPR's road maintenance expenses over the period of 1980-1988 on passenger train kilometres, freight train kilometres and route length[26]. The ratio (0.90) of estimated coefficients associated with the passenger and freight train kilometres is used to allocate the total road maintenance personnel between passenger and freight services. All data on CNR and CPR are obtained from Statistics Canada catalogues 52-215, 52-216.

The full time equivalent number of employees of Amtrak, including both Amtrak's own employees and the employees of the operating freight railroads who work for passenger rail services under contracts with Amtrak, are provided by Amtrak's Department of Human Resource. This number is adjusted to include Amtrak's share of the freight railroads' road maintenance personnel. The U.S. class I railroads' average number of road maintenance personnel per route kilometre compiled from **Railroads Facts** published by AAR, is used to estimate the number of road maintenance personnel over the Amtrak's route. This estimated road maintenance personnel is then allocated between passenger and freight services using the same ratio (.90) of passenger train kilometres to freight train kilometres as used for VIA Rail.

---

[26] The data on CNR's route length is available only for 1980 and 1981. For other years route length is estimated by assuming that the ratio of route mileage to track mileage is fixed.

The total numbers of employees of the European railways, JNR and KNR are obtained from **International Railways Statistics**, AN's number of employees is obtained from its annual reports. These railways provide mixed passenger and freight services. Total number of rail employees for these railways is allocated between passenger and freight services on the basis of train kilometres using linear regression analysis. The estimated ratio of freight train labour requirements to passenger train labour requirement is 0.73. This ratio is then used to compute the labour inputs for passenger services.

(B) Locomotive

VIA Rail's number of locomotives is obtained from Statistics Canada catalogues 52-215 and 52-216. Amtrak and AN's number of locomotives are obtained from their annual reports. The total numbers of locomotives for the rest of the sample railways are obtained from **International Railway Statistics**.

Except for VIA Rail and Amtrak, all of the railways in the sample provide both freight and passenger services. A linear regression was used to allocate the total number of locomotives for these railways between passenger and freight services on the basis of train kilometres hauled by locomotives[27]. The number of "passenger locomotives" is computed using the estimated ratio (0.89) of freight train locomotive requirements to passenger train locomotive requirements.

---

[27] The railways operate two types of trains. Some trains are hauled by locomotives while others are made up of self-powered cars.

(C) Energy Consumption

Energy input is measured by total BTUs consumed, using the following conversion factors:

Diesel oil :	0.1657 million Btu / imperial gallon
Fuel oil:	0.1801 million Btu/ imperial gallon
Electricity:	3412 Btu/KWH
Coal:	26.2 million Btu/ton

1 ton of diesel oil = 1.571 tons of coal.

VIA Rail's energy consumption data for the 1985-1988 period are obtained from Statistics Canada. Since Via Rail's data for earlier years are not available, they are estimated. Amtrak's energy consumption data is readily available from **National Transportation Statistics.**[28] Actual fuel consumption data for AN is not available, it is estimated by dividing fuel expenses by yearly average diesel prices in Australia published in the OECD publication **Energy Prices and Taxes.** The remainder of the sample railways' energy consumption for 1978-1984 are obtained from **International Railways Statistics.** Energy data for the European railways for 1985-1987 are obtained from **Statistical Trends in Transport 1965-1987**[29]**,** the data for 1988 are estimated using BTU per train kilometres in 1987. JNR's energy consumption for 1985-1986 are obtained from **Statistical Yearbook of Japan**.

---

[29] An OECD publication prepared by the European Conference of Ministers of Transport (ECMT).

The total energy consumption for the "mixed" railways is allocated using a regression on passenger train kilometres and freight train kilometres. The resulting ratio (0.95) of freight train energy requirement to passenger train energy requirement is used to allocate total BTU between passenger and freight services.

Because of the lack of availability of better data, the length of rail lines is used as the ways and structures input. An attempt was made to distinguish total passenger route kilometres into two types: electrified and non-electrified (see Table 8).

5.2 Environmental and Production Characteristics Variables

5.2.1 Environmental Variables

Environmental variables refer to those variables describing the economic conditions and population distribution of the nation, the extent of development of other passenger transport modes, and the regulatory, institutional and ownership arrangements of the industry.

GDP per capita (Table 1) serves as an indicator of a country's economic situation and is obtained from **National Accounts, Vol.1**[30] and **International Financial Statistics**. Population density (Table 2) is calculated by dividing mid-year population estimates by surface area, which are obtained from **The Europa World Year Book** and some countries' yearbooks. These two variables are likely to affect the demand for travel, and thus the observed efficiency of the passenger railways. Market shares of rail in the passenger transport market is calculated in terms of passenger kilometres. This variable indicates the extent of intermodal competition.

---

[30] An OECD Publication.

A set of dummy variables is used to indicate ownership form and institutional arrangements of the railways. These include one variable for quasi-public firm, one for government agency, and one for passenger railways.

5.2.2 Production Characteristics Variables

Passenger traffic density is measured by passenger kilometres per route kilometre (Table 11). Average length of trip (Table 6) indicates the type of passenger traffic, that is, long distance vs commuter traffic. Percentage of passenger train kilometres in total train kilometres (Table 7) indicates the importance of passenger services in the railways' overall operation. Electrification rate (Table 8), measured by the percentage of electrified lines in total rail lines operated, indicates the state of technology being employed and the extent of infrastructure investment. The revenue-cost ratio and subsidy-cost ratio (Table 9 and Table 10) indicate the commercial viability of the railways.

VI. Railways' Performance over Time

This section first presents partial measures of productivity for the sample railways. This is followed by the application of the DEA method to measure and compare the overall efficiency performance of the railways. Before proceeding, however, it is important to review the financial performance of our sample railways briefly.

6.1 Financial Performance of the Sample Railways

With the exceptions of BR and Australian National[31], most of the railways providing mixed passenger and freight services do not report separate revenue-expense accounts for passenger services. The financial data referred to in this section represent the overall financial performance of the railways (both passenger and freight). Table 9 presents the operating cost recovery ratios for our sample railroads, while the ratios of direct subsidy to total operating cost are reported in Table 10. It is useful to note that the subsidy ratio is not necessarily equal to (1 - operating cost recovery ratio), because a few railways receive balancing subsidies and some railways such as JNR and DB finance some of their deficit by raising debt.

Among the 21 railways, Italian State Railways (FS) has the lowest revenue-cost ratio (22% in 1988) with Luxembourg (CFL), Greece (CH) and VIA Rail Canada doing slightly better (23%, 28% and 28%, respectively, in 1988). The operating revenues of JR system (Japan), China Railways and Pakistan Railways exceed their respective operating costs in 1988. Korean National Railways (KNR), British Rail (BR), Australian National Railways (AN), and Swedish State Railways(SJ) also enjoy fairly high operating cost recovery ratios: 96% for KNR, 92% for BR[32], 86% for AN, and 81% for SJ in 1988. It should be noted that JR system's cost recovery ratio improved significantly after the breakup of the old JNR system into the current JR system in 1987 (operating cost recovery ratio improved to 112% in 1988 from only 59% in 1986). BR's financial performance has also improved significantly since its reorganization in 1982 (improved from 61% in 1982 to 92% in 1988) while Swedish State Railways (SJ) has remained relatively stable at about an 82% operating cost recovery.

---

[31] Australian National's Passenger and Travel Division became a separate business segment in December 1988.

[32] BR's Intercity sector has achieved an operating surplus since 1988.

Until about 1980, Italian State Railways (FS), VIA Rail Canada, Luxembourg Railways (CFL), Amtrak and Belgium National Railways (SNCB) were the worst performers in terms of the operating cost recovery ratio: FS 29%, VIA 31%, CFL 31%, Amtrak 39% and SNCB 44% in 1980. However, since then Amtrak's performance has consistently improved to reach 63% operating cost recovery in 1988 while the performances of VIA, CFL, CH and FS deteriorated to 28%, 23%, 28% and 22%, respectively, in 1988. SNCB's cost recovery ratio remained nearly the same at about 43-44% for the 1980-88 period. It should be noted that most of the highly subsidized railways, including FS, VIA, Amtrak, SNCB, and CFL (Luxembourg), provide primarily passenger services with passenger train kilometres accounting for more than 75 percent of their total train kilometres.

6.2 Traffic Density

Passenger kilometres per route kilometre (Table 11) is, probably, the most important measure of passenger traffic density. JNR, KNR, NS, and CFF are the carriers with the highest traffic density (average density of 9.7 million for JR in 1987, 7.2 million for KNR in 1984, 3.8 million for NS, and 3.7 million for CFF in 1988) while AN, Amtrak and VIA Rail Canada are low density carriers (33,000 passengers for AN, 217,000 passengers for Amtrak and 124,000 passengers for VIA). For most railroads including Amtrak, the traffic density increased over the 1978-88 period while VIA Rail Canada experienced a significant drop in its traffic density. As expected, most European carriers except those of Scandinavian countries and CFL (Luxembourg) have fairly high traffic density: above 1.4 million passenger km per route km. Sweden's SJ, Norway's NSB, and Finland's VR have an average density of 648,000, 519,000 and 721,000 kms per route km, respectively.

6.3 Labour productivity

Passenger kilometres (RPK) per employee (Table 12) is used as the primary indicator for labour productivity. JNR and KNR enjoy the highest labour productivity, 1.1 million RPK per employee for JNR and 790 thousand for KNR, followed at a distance by SNCF (432 thousand RPK per employee), NS, Amtrak and RENFE. The labour productivities of the CFF, SJ, DSB and CP (Portugal) are on the high side as well.

CFL and AN have the lowest labour productivites. Most of the railways have improved their labour productivity over the period, except VIA Rail and CFL. While CFL's labour productivity has remained relatively stable, VIA's labour productivity has deteriorated. Some railroads including Amtrak, British Rail, DSB, JNR, SJ, SNCF and VR have experienced significant improvements in their labour productivity during the 1978-88 period[33].

6.4 Rolling Stock Productivity

Rolling stock productivity is measured by passenger kilometres (RPK) per passenger car. These are reported in Table 13; JNR and KNR achieved the highest passenger car productivity (8.2 million RPK per car for JNR and 8.4 million for KNR) among the sample railways, while AN and SNCB had the lowest passenger car productivity (1.0 million and 1.9 million RPK, respectively). VIA Rail Canada's rolling stock productivity was at about the middle of the pack (3.2 million kms). Amtrak's passenger car productivity improved significantly over the sample period. Other railways have either improved their passenger car productivity or maintained a stable level during the period.

---

[33] The lowest labour productivity for BR occurred in 1982 as a result of railway strikes.

6.5 Energy Productivity

The energy productivity was measured as passenger kilometres (RPK) per million BTU consumed in the passenger operation (Table 14). AN, VIA Rail and Amtrak are the least energy efficient. While Amtrak's energy productivity improved significantly during the sample period, AN and NSB's energy productivities deteriorated significantly during the period. JNR enjoys the highest energy productivity by far with CFF, FS, SNCF, NS, CP and KNR exhibiting high energy productivity.

Summary of partial measure of productivities: JNR of Japan and KNR of Korea have the highest partial factor productivity in every dimension. Amtrak, CFF, NS, SNCF, Renfe, and DSB appear to enjoy high partial factor productivity in 1988. JNR, Amtrak, BR, DB, DSB, RENFE, SJ, SNCF and VR have improved labour productivity substantially during the 1978-88 period (BR since 1982, and JNR since 1984). VIA Rail Canada and CFL (Luxembourg) are the only firms in which labour productivity decreased during the 1980s. Amtrak, BR, CFF and DB improved the productivity of rolling stock significantly during the sample period. NSB and AN have experienced the most noticeable decrease in energy productivity during the sample period.

6.6 Efficiency Comparison and Analysis by DEA

It is difficult to make any accurate inference about a firm's productive efficiency relative to other firms with any one of the partial measures of productivity examined above because each partial factor productivity (say, labour productivity) is influenced by the intensity of using one or more of the other inputs (e.g., intensity of capital input). Therefore, it is necessary to find a measure which allows the comparison of the overall efficiency of a firm relative to other firms

in the sample. As stated in section III, we have chosen to use the so-called data envelopment analysis (DEA) method to compute such an overall efficiency index.

In this study, each observation (i.e., combination of railway and year) is regarded as an individual "decision making unit" (DMU)[34]. In total, we have 242 DMUs available for solving the LP problems in equation (2).

Each DMU is assumed to produce one output -- passenger kilometres, using four inputs: labour, locomotives, passenger cars, and route length. Since most railway rights-of-way are shared by passenger and freight traffic, the use of total route length tends to overestimate the actual input for passenger services. The smaller the proportion of passenger traffic, the more the input for passenger services gets overestimated. Therefore, the percentage of passenger train kilometres in a network's total train kilometre is later used in Tobit regression analysis in order to correct for the potential bias. Electrified route and non-electrified route represent different scales of investment and should be incorporated separately. However, some of the railways still rely entirely on fuel traction which means that they have 0 kilometres of electrified route length. The DEA method cannot produce a meaningful efficiency index for those DMU with 0-input. Therefore, total route length is used, and the electrification rate is used to correct for this effect later in the Tobit regression.

To compute the DEA efficiency ratings, the LP problem in (2) must be solved once for each DMU (observation). The DEA efficiency index obtained by solving the LP problem is very sensitive to outliers as they tend to form the frontier technologies to which the rest of

---

[34] It is assumed that all decisions regarding operations are made at the firm level.

observations are being compared[35]. In our application, JNR and KNR were clear outliers because of their unusually high partial factor productivity in all dimensions. Therefore, we left out the JNR and KNR data when we computed the DEA efficiency index. It is clear that JNR (even before the breakup in 1987) and KNR enjoyed far higher productivity than all other railroads in our sample, probably because of their high population density and their heavy reliance on the rail mode for passenger transportation.

Table 15 reports the results of the DEA efficiency index. An index value of 1.0 indicates that the corresponding DMU is the most efficient entity. In other words, the DEA index value of 1.0 implies that the entity is right on the efficient production frontier. The DEA index in Table 15 shows that (in addition to JNR and KNR which are excluded due to being outliers), Amtrak, BR (British Rail), CFF (Swiss), FS (Italy)[36], NS (Netherlands), Renfe (Spain), SNCF (France) and CP (Portugal) have reached close to the efficient production frontier by 1988. BR and Amtrak had achieved the largest improvement: 0.57 in 1978 to 1.0 in 1988 for BR, and 0.63 in 1978 to 1.0 in 1988 for Amtrak. DSB, CFF, CIE (Ireland), SNCF and SJ are among the high improvers as well.

DB(Germany), NSB (Norway), ÖBB (Austria), SNCB (Belgium), CH(Greece), CFL(Luxembourg), AN(Australia), and VR (Finland) are the low achievers, their DEA efficiency index values are lower than 70% in 1988. Among these low achievers, only VIA Rail, CFL (Luxembourg) and NSB (Norway) experienced significant decline in their DEA efficiency index

---

[35] Due to the inadequacy of DEA in dealing with outlier and boundary point problems, we have also used alternative methods of measuring the railways' efficiency. The results of these alternative methods are discussed later in this report.

[36] FS's high index is most likely due to its relatively high energy productivity. When energy is excluded from the input set, it gets lower efficiency index.

during our sample period. VIA's index declined from 0.76 in 1980 to 0.62 in 1987. VIA Rail's improved rating in 1988 (DEA index value of 0.70) is probably due in part to increased ridership as a result of the major bus strike which occurred in that year, and may also be due to the fact that VIA Rail had gained greater control over the resources it needs by taking over most of the equipment and facilities needed to run a passenger rail service[37].

Although this DEA index represents the productive efficiency of the inputs considered (labour, energy and capital), this index does not control for the effects of variables beyond managerial control. For example, the efficiency of a passenger rail system may be influenced by traffic density, ownership form, degree of regulatory and political control on the management, climate and topography, degree of intermodal competition, average length of passenger trips, mix between freight and passenger services, extent of electrification, and extent and method of public subsidy. Yet these factors are largely beyond managerial control. Therefore, in the following section an attempt is made to identify the net (including managerial) efficiency of the system by identifying and controlling effects of the variables beyond managerial control.

VII. Effects of the Policy Options and the Variables Beyond Managerial Control

The DEA efficiency ratings reported in the previous section are considered a gross (observed) efficiency index. Since they are influenced by factors over which the railways have no control, they are not likely to represent the true managerial or technical efficiency. Therefore, in order to compare the managerial and technical efficiency of the system, the effects of these

---

[37] The only operating element still beyond VIA Rail's control was the tracks over which VIA Rail operates, which belong to CNR and CPR.

variables must be controlled for. Furthermore, identification of the effects of these variables on DEA efficiency itself is important for evaluating future policy directions.

The factors examined initially include: (1) rail's share in each country's passenger transport market, a variable partially reflecting the level of demand for passenger rail service; (2) traffic density, as measured by passenger-km per route-km where high density is likely to give higher gross efficiency ratings; (3) the percentage of passenger train kilometres in total train kilometres[38] which is intended to remove the effects of freight services; (4) average passenger trip length (passenger kilometres divided by number of passengers); (5) degree of electrification (percentage of electric route miles); (6) degree of management autonomy as measured by Compagnie, Gathon and Pestieau (1991, p.8)[39]; (7) dummy variables indicating ownership form; one for quasi-public firm, one for government agency setting, and the default is public firms; (8) a dummy variable indicating the control of intermodal competition for the traffic over certain distances (Germany, Italy and France); (9) passenger service only vs mixed passenger and freight service is also examined through the use of a dummy variable; and (10) technical progress is represented by a time-trend variable. Table 16 lists the definitions of the variables to be examined. Some of these factors are considered controllable by governments while others are uncontrollable (e.g., traffic density, network size, climate, topography, etc.).

---

[38] The percentage of passenger train kilometres in the total train kilometres for Canadian Class I railways is used for VIA Rail. The percentage of passenger train kilometres in the total train kilometres for US Class I railroads (including Amtrak) is used for Amtrak.

[39] Since Compagnie, Gathon and Pestieau measured the degree of management autonomy for European railways at a point in time, it was necessary to assume that the railways' autonomy ratings remain unchanged during the study period. In addition, VIA Rail, JNR and KNR are given the lowest rating, and Amtrak and AN are given the same rating as BR.

7.1 Regression Analysis on Partial Factor Productivities

In order to understand how variables beyond managerial control influence productivity, three partial factor productivity measures (labour productivity[40], energy productivity and rolling stock productivity reported in section 6) are first analyzed. The results of the log-linear productivity regressions are reported in Table 17. The regression results can be summarized as follows:

(a) **Effect of traffic density and average distance of passenger trips:** These two factors which are largely beyond a railway's control influence all three partial factor productivity levels significantly. As expected, the countries with higher traffic density (passenger kilometres per route km) and/or longer average trip distance enjoy significantly higher labour, energy and rolling stock productivity than other countries.

(b) **Effect of electrification:** After controlling for the effect of traffic density, the percentage of electrified routes in the total route increases energy productivity, and decreases rolling stock productivity, but has no statistically significant effect on labour productivity. The negative effect on rolling stock productivity may have been caused by the high collinearity between traffic density and the % electrification variable.

[40] Excluding way and structure personnel.

(c) **Effect of government subsidy[41]:** The proportion of subsidy in the total operating cost has a statistically significant negative effect on all of the three partial factor productivity measures. This implies that as the proportion of subsidy increases, the passenger rail operations become less efficient. This result is consistent with the empirical results in previous studies including Kim and Spiegel (1987). Our result indicates that an increase in the subsidy ratio by 10% is likely to reduce labour productivity by 0.7%, energy productivity by 0.2%, and rolling stock productivity by 0.4%.

(d) **Effect of government agency:** DB (Germany, 1978-88), DSB (1978-1985), and FS (1978-84) were owned and operated by government agencies. In order to identify the effect of a government agency operation, a dummy variable was included in the productivity regressions. The government agency variable shows a statistically significant negative effect on all three partial productivities. Specifically, other things being equal, passenger services run by a government agency are likely to experience about 11% lower labour productivity, 18% lower energy productivity, and 15% lower rolling stock productivity.

(e) **Effect of forming passenger only corporation:** Canada and the United States essentially formed single corporations in order to take over their nation-wide intercity passenger rail services, whereas in most other countries rail passenger carriers provide freight services as well. In order to identify the effect of forming

---

[41] (1-revenue/cost ratio) is used as CFF's subsidy/cost ratio. The missing data on subsidy-cost ratio for RENFE are interpolated from the previous and following years' data.

a single passenger only corporation, a dummy variable "Passenger Only" was included in the productivity regression. The result indicates that **a single nation-wide passenger only corporation results in lower energy productivity, but higher labour and rolling stock productivities.** The effect on overall productivity is positive as the share of energy in total input cost is quite small. In 1985, Japan took the initiative to break up the JNR system into six regional passenger and one freight rail corporations (the actual breakup occurred in April, 1987). This appears to have improved JNR's productivity substantially from 1985. In view of the positive Japanese experience in creating a passenger only corporation, this issue requires a further in-depth investigation.

All other variables identified as potentially influencing productivity were not statistically significant at any reasonable level.

7.2 Effects of the Policy Instruments and the Uncontrollable Variables on DEA Index

A preliminary experiment with the Tobit model shows that the log-linear functional form yields considerably better statistical results than the linear functional form. Note that LEFF, logarithm of the gross DEA efficiency index, is used as the dependent variable with the constraint that the predicted value (log of the DEA index) does not exceed zero[42]. Several alternative sets of controllable and uncontrollable variables were experimented with, and the models were chosen on the basis of both statistical tests and properness of the coefficients. In searching for the

---

[42] In the actual estimation, the sign of the dependent variable, logarithm of DEA index, is reversed; the "new" dependent variable is, in fact, the log of the reciprocal of the gross DEA index. By doing so, we just need to do a traditional TOBIT regression with a lower bound of zero. For ease of interpretation, the regression results are reported in accordance with the original form.

models, when the autonomy variable is used in the model, we excluded the dummy variables indicating ownership forms (Govt. Agency, Quasi-Public or Public Corp.), and vice versa.

Table 18 reports the two best TOBIT regressions, one with the autonomy variable, and another with ownership form dummy variables. Although the two Tobit regressions are similar in terms of the empirical results, Model 2 is considered to be statistically superior due to its higher likelihood function value. The results can be interpreted as follows:

(a) **Effect of uncontrollable variables:** Three variables which are largely uncontrollable by management or governments are included in the Tobit regression: DENSITY, passenger traffic density (passenger kms/route kms), TRIP LENGTH, average trip distance (passenger kms/passengers), and %PASSENGER (percentage of passenger train-kms to the total train-kms in the system). Both DENSITY and TRIP LENGTH variables have statistically significant positive coefficients in the Tobit regression, implying that, other things being equal, the railways with higher passenger traffic density and/or longer average trip distances are expected to enjoy considerably higher DEA efficiency index than other railways. The %PASSENGER variable also has a positive and statistically significant coefficient. This implies that railroads with higher percentages of passenger services are expected to achieve higher DEA efficiency indexes. For our particular case, there are two reasons why this is expected. First, as a railway does a relatively large share of business in passenger services, they are likely to focus on improving efficiency of passenger operation. Second, the route miles were used as the indicators of ways & structure input for the passenger services when, in fact, these route miles are used for both freight and passenger services.

As stated previously, this makes the ways and structure inputs more over-estimated for the carriers with heavier emphasis of their business on freight services than for those with less emphasis on freight. Therefore, the inclusion of the %PASSENGER variable corrects for the effect of over-estimating ways & structure inputs on the DEA efficiency index.

(b) **Effects of Electrification:** The %ELECTRIC variable has a statistically significant positive coefficient. Electrified rail lines are believed to require higher investment than non-electrified routes, thus using total route mileage in DEA analysis underestimates the ways and structure input for highly electrified railways. Therefore, the positive coefficient for %ELECTRIC helps to correct this problem. The positive coefficient for %ELECTRIC also captures the positive effect of electrification on energy productivity.

(c) **Effect of Subsidy:** Unlike the case of the partial factor productivity regressions, the ratio of subsidy to the total operating expenses is only marginally significant in Model 1 (at 10%) but is not significant in Model 2. The negative coefficient implies that there is some evidence that a passenger railway gets less efficient as the percentage of subsidy in the cost increases. This weak linkage between subsidy and efficiency may be due to the negative correlation between the subsidy variable and the autonomy or ownership variables. Therefore, it may be incorrect to interpret this to mean that subsidy level does not affect efficiency adversely.

(d) **Effect of Ownership Form and Managerial Freedom**: In Model 1, we use the autonomy index to examine the effects of managerial freedom. The significant positive coefficient of AUTONOMY in the TOBIT analysis indicates that the railways' efficiency could be improved significantly if the management were given more freedom over decisions regarding the railways' strategic and operational decisions. In Model 2, the ownership dummy variables are included to examine the effects of ownership form. The dummy variable for Quasi-public firms is not statistically significant. This implies that the existence of partial private ownership does not necessarily make the railways much different from other public firms when it comes to government control.[43] The Government Agency Ownership and Operation variable has a significant negative coefficient. This indicates that, after controlling for the other factors, passenger services provided by a government agency are about 17% less efficient. This is consistent with the results of our partial factor productivity regressions. DB has been owned and operated by the German Government agency for the entire sample period while DSB was owned and operated by a Danish government agency until 1985, and FS by a Italian government branch until 1984. These results show that managerial freedom is what really affects the railways' efficiency performance. The mixed ownership form may or may not affect the degree of autonomy the management has; however, it is clear that railways operated by a government agency tend to have less managerial freedom.

[43] In a private communication, Professor C. Nash indicated that he does not believe the nominal 49% private shareholding in SNCF made it in any sense different from other state owned railways when it came to government control.

(e) **Effect of Passenger Only Corporation:** The significant positive coefficient for the **'PASS ONLY'** dummy variable indicates that the experiment by Canada and the U.S in setting up a single passenger only corporation to handle virtually all intercity passenger services is likely to have improved efficiency. This result is consistent with the findings of a previous study by Kim (1987)[44] as well as our partial factor productivity regression results.

The above results from the Tobit regression indicate that a passenger railway's efficiency performance is significantly influenced by the extent of managerial freedom for decision making, as evidenced by the significant negative effect of the Government Agency dummy variable and the positive effect of the autonomy variable. Subsidy levels have negative effects on efficiency. Essentially the same results were obtained from the partial factor productivity regression analysis as well.

7.3 Net DEA Efficiency Measures and Comparison Among Railways

Net efficiency ratings are obtained from the residuals of the Tobit regression (2) after removing the effects of those factors beyond managerial control, and the results are listed in Table 19. Model 2 is used mainly for two reasons: first, Model 2 is considered to be statistically better than Model 1, because the former has a higher log-likelihood function value and R^2 value[45]; second, information on the autonomy index is available only for the European railways for 1988. The information on how they changed over time is not available. Furthermore,

---

[44] The study found that the US railroads suffered from diseconomies of scope associated with the joint production of freight and passenger services.

[45] Strictly speaking, Model 1 and Model 2 can not be easily compared as there is no nesting relationship between the two.

we had to use our judgement for the autonomy levels for Amtrak, AN, and VIA Rail. In the Tobit regression, we are forced to assume that the autonomy index remains unchanged during the 1978-88 period.[46] Controlling for the effects of the government policy variables and other variables beyond managerial control, results in net efficiency index numbers which are closer together than the gross efficiency indexes. The results show that, in 1988 CP (Portugal), CIE (Ireland), TCDD (Turkey), and RENFE (Spain) are the efficient performers after controlling for the effects of the variables beyond managerial control. NSB (Norway), ÖBB (Austria), SNCB (Belgium), CH (Greece), DB (Germany) and CFL (Luxembourg) are the inefficient performers.

It is noted that, in terms of the gross DEA efficiency index, AMTRAK, CFF, NS and SNCF are among the top performers. The control reduced their performance from the top to the middle level. On the other hand, control of the variables beyond managerial control improved the efficiency rankings of AN (Australia) and CIE (Ireland). Furthermore, in terms of net efficiency ratings, more railways belong to the group of "middle level" performers with similar efficiency ratings. NSB, ÖBB, SNCB, CFL and CH have low efficiency ranking in terms of both the gross and the net DEA efficiency indices.

VIA Rail's efficiency rating is reduced in numerical value, but the difference between Amtrak and VIA Rail is significantly reduced which may be explained by the following: (a) Amtrak has a higher traffic density, e.g., a larger market, and a longer average passenger trip length than Via Rail has; these two factors have significant positive effects on railways' gross efficiency; (b) a portion of Amtrak's network (the Northeast corridor routes) is electrified while

---

[46] This may be an unrealistic assumption. For example, since the early 1980s BR and SJ were given more freedom for managerial decision making.

Via Rail still entirely relies on fuel traction; this also contributes, to some degree, to Amtrak's higher gross efficiency; (c) VIA Rail's higher subsidy-cost ratio has a negative effect on the gross efficiency.

VIA Rail's (gross) efficiency in 1988 was 30% lower than that of Amtrak (see Table 15). However, after controlling for the differences in traffic density, average passenger trip length, the percentage of electrified routes, and the level of government subsidy, the difference in net (including managerial) efficiency is reduced to about 10%. In other words, the differences in VIA Rail's operating environment and the government policy towards VIA Rail (which is politically motivated, and beyond managerial control) is to blame for about two thirds of the VIA Rail's productive inefficiency as compared to Amtrak. However, it is important to point out that neither VIA Rail's gross efficiency nor net efficiency improved during the 1980-88 period, while Amtrak improved gross and net efficiency by about 25% and 15%, respectively. In fact, VIA Rail's gross efficiency fell by about 9% during the 1980-88 period.

Amtrak, BR, CIE (Ireland), DSB(Denmark) and SJ (Sweden) have improved their net efficiency significantly during our sample period while the performance of FS (Italy) and NSB (Norway) fell significantly during the same period.

7.4 Efficiency Analysis by Production Frontier Function

As mentioned in Section VI, DEA can not effectively deal with outliers and boundary (0-input) problems. Therefore, in this section we attempt to examine the effects of the policy variables and the uncontrollable variables on the performance of the passenger rail systems by estimating the production function specified in equation (4). The results from the production

functions are compared to the results from the DEA-TOBIT analysis to see if our empirical results are sensitive to the methods chosen. The comparison shows that, by and large, the empirical results from the two methods are very similar.

Although essentially the same data set is used here, this time the production method allows us to retain the data for JNR and KNR. In estimating the production function, we use passenger kilometres as the dependent variable for output, and use number of passenger cars, number of locomotives, employee numbers, and BTU consumed as well as the lengths of electrified line and non-electrified lines as independent variables for inputs. In addition to those output and input variables, we also included the policy variables and the uncontrollable variables (which were used in the TOBIT analysis) directly in the production function.

The estimated production functions are reported in Table 20. The first five variables are inputs. As expected, DENSITY and TRIP LENGTH variables have statistically significant positive coefficients. SUBSIDY has a significantly negative coefficient (-0.05) implying that government financial support tends to decrease the railways' efficiency. In particular, as subsidy increases by 10%, productive efficiency decreases by 0.5%. The autonomy variable has a positive coefficient but is not statistically significant. This is probably due to the inclusion of JNR and KNR[47]. It can be explained by the fact that JNR and KNR are both highly efficient according to the partial productivity numbers, but they are given the lowest autonomy ratings. Their high efficiency levels are in part due to the fact that they have a much larger market than

[47] When the production function is estimated over the data set excluding JNR and KNR, the autonomy variable has a significant positive coefficient.

the other railways[48]. Similarly, SUBSIDY is statistically significant in Model 2 while it is not significant in Model 2 of the TOBIT regression when JNR and KNR are excluded because JNR and KNR both have low subsidy levels and high efficiency levels. The GOVERNMENT AGENCY variable in Model 2 has a significant negative effect. The positive coefficient for the PASS ONLY dummy variable is also consistent with the results from TOBIT analysis. The results of the production function estimation essentially confirm those of the DEA - TOBIT combined analysis.

The constructed best practice frontier depends greatly on the particular set of sample railways involved, and this can lead to different efficiency ratings. To compare the efficiency ratings from the DEA-TOBIT analysis and those from the production frontier function, the production function is reestimated after removing JNR and KNR's data. In Table 21, the net efficiency measures obtained from the production function (defined in Equation (6)) are compared with the DEA-TOBIT results. With a few exceptional cases, the results are, by and large, very similar. Model 2 of the production function is used for the same reasons as Model 2 of the TOBIT regression. CP (Portugal) and RENFE (Spain) are still the top performers as indicated by the DEA-TOBIT results, while CFL (Luxembourg), ÖBB (Austria) and SNCB (Belgium) are the least efficient railways. Noticeable differences exist in the efficiency ratings obtained by the two methods for some railways such as CFF (0.60 by DEA as compared to 0.74 by production function). The two methods yield essentially the same net efficiency index numbers for VIA Rail and Amtrak.

---

[48] Their market shares in passenger transportation are much higher than those of the other railways.

VIII. Summary of the Findings and Policy Implications

The paper examines and compares the economic efficiency of the railways in 21 selected countries using partial productivity measures, the gross DEA efficiency index, and the net (including managerial) efficiency index.

The partial productivity measures and gross DEA efficiency ratings are analyzed by econometric procedures to accomplish two tasks: (a) to identify the effects of the controllable and uncontrollable variables on the partial productivity measures and the gross measure of DEA efficiency index; and (b) to compute the net efficiency index after controlling for the effects of the variables which are beyond managerial control. The production function provides an alternative technique to examine the effects of the controllable and uncontrollable variables on the performance of the passenger rail systems.

The results can be summarized as follows:

(a) JNR, KNR, CP, and RENFE are the top performers in productivity and efficiency in 1988. This finding is true both before and after controlling for the effects of the variables beyond managerial control. NS, CFF and SNCF were also in the top performance category in terms of partial factor productivities and gross DEA efficiency index. However, after controlling for the effects of the variables beyond managerial control, these firms rank somewhat below the top performers.

(b) JNR, Amtrak, BR and DSB have improved productive efficiency significantly during the 1978-88 period on virtually all criteria.

(c) AN, DB, NSB, ÖBB, SNCB, CH and CFL are the inefficient performers across all criteria, i.e., partial factor productivities and gross and net efficiency indices.

(d) Our analysis of the gross DEA efficiency index and partial factor productivities as well as the estimated production function indicates that the efficiency performance of the passenger rail system is significantly enhanced by institutional and regulatory frameworks, which gives greater freedom for managerial decision making.

(e) There is fairly convincing evidence to support the establishment of a single national passenger-only corporation like VIA Rail Canada and Amtrak.

(f) An increase in subsidy (ratio of subsidy to total operating cost) lowers the efficiency of the passenger rail operation, ceteris paribus.

In view of these results, we conclude that freedom of managerial decision making is an important element for improving the efficiency of a passenger rail system. Therefore, the institutional and regulatory framework for passenger system must squarely address this question. A high level of government subsidy without setting explicit cost recovery targets will tend to reduce the level of efficiency. By and large, these results are consistent with those of previous

European studies such as Nash (1991), Perelman and Pestieau (1988), and Compagnie, Gathon and Pestieau (1991).

VIA Rail's (gross) efficiency in 1988 was 30% lower than that of Amtrak. However, after controlling for the differences in traffic density, average passenger trip length, the percentage of electrified routes, and the level of government subsidy, the difference in net (residual) efficiency is reduced to about 10%. In other words, the differences in VIA Rail's operating environment and the government policy toward VIA Rail (which is politically motivated, and beyond managerial control) is to blame for about two thirds of the VIA Rail's productive inefficiency as compared to Amtrak. However, it is important to point out that neither VIA Rail's gross efficiency nor net efficiency improved during the 1980-88 period while Amtrak improved gross and net efficiency by about 25% and 15%, respectively. While there is room to improve VIA Rail's managerial efficiency, a bigger gain in efficiency would be achieved if the federal government gave substantial autonomy (along with accountability for the results) to VIA Rail management for making important strategic and market decisions.

Our empirical results indicate that (a) the creation of a single nation-wide passenger rail corporation (VIA Rail Canada) was a positive step for improving efficiency; (b) the federal government's tight control on VIA Rail's strategic direction, market (particularly the exit control) and pricing decisions have adversely affected VIA Rail's productivity performance; (c) financing the deficit through subsidy without setting explicitly cost recovery and productivity enhancement and service quality improvement targets have also adversely affected VIA Rail's productivity. Although our analysis did not include the issue of public disclosure of the cost and performance indicators on VIA Rail, the analysts who looked into the passenger rail system in Canada agree

that the protection of cost and input data (particularly the transactions between VIA Rail and the two transcontinental freight railroads) from public scrutiny discourages and perhaps prevents independent analysts from evaluating VIA Rail's performance.[49]

Our recommendation to the federal government is simple and clear. VIA Rail management should be given more autonomy for making strategic decisions of the corporation, choice of markets, and pricing decisions. The government in collaboration with the management should set the targets for cost recovery and productivity and service quality improvements. The cost recovery target should reflect best practice productivity improvement factors. Where it is necessary to keep passenger rail services for social reasons, the government must compensate VIA through explicit social contracts similar to the practices in some European countries. VIA Rail should be given equal status to negotiate fees for the services provided by the freight railroads and for the use of rail infrastructure. Information on the costs and inputs, and some essential information on the transactions between VIA Rail and the freight railroads, must be made public[50] in order to make the performance transparent and to enforce management's accountability.

---

[49] The present authors experienced that, as citizens of Canada, it is more difficult and time-consuming to get any VIA Rail data than the same data from 20 other railroads around the world included in this study. In the end we had to use estimated values for some VIA Rail data. It is inconceivable to think that the number of CNR and CPR employees who worked for VIA Rail's passenger services is confidential, and thus not available even to the principal investigator for this study, which is commissioned by the Royal Commission on National Passenger System (Mr. Michael D. Parry, Director General of National Transportation Agency's Transportation Subsidy Branch, confirmed this in a letter to us). Mr. J. Roger Paquette, Vice-President, VIA Rail Canada, confirmed in his letter to us that VIA Rail does not have the number of CN/CP employees assigned to VIA operations during the 1979/89 period because VIA's operating agreement with CN and CP made no provision for such data to be supplied in support of the compensatory payments. We would like to ask what they do when someone bills them nearly $400 million without an explanation.

[50] This may require a change in Statistics Canada Act, which is far more protective of business information than necessary.

REFERENCES

Aigner D. J., T. Amemiya and D.J. Poirier (1976), "On the Estimation of Production Frontiers", International Economic Review, Vol. 17. No.2, June 1976, 377-396.

Aigner D.J., C.A.K. Lovell and P. Schmidt (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models", Journal of Econometrics, 6, 21-37.

Amemiya, T. (1985), Advanced Econometrics, Harvard University Press, Cambridge, Massachusetts.

Banker, R.D., A.Charnes, W.W. Cooper and A. Maindiratta (1988),"A Comparison of DEA and Translog Estimates of Production Frontiers Using Simulated Observations From a Known Technology", in Applications of Modern Production Theory: Efficiency and Productivity, A. Dogramaci and R. Färe (eds.), Kluwer Academic Publishers, Boston. 33-55.

Bureau of Transport and Communication Economics (1988), A Comparison of Overseas Railway Systems: Their Policy Trends and Performance, Information Paper 30, AGPS, Canberra.

Caves, D., L. Christensen and E. Diewert (1982) "Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers", Economic Journal, 92, 73-86.

Charnes, A., W.W. Cooper and E. Rhodes (1978), 'Measuring the Efficiency of Decision Making Units', European Journal of Operational Research, 2, 429-444.

Charnes, A, W.W. Cooper, D.B. Sun and Z.M. Huang (1989), 'Polyhedral Cone-Ratio DEA Models with AN Illustration Application to Large Commercial Banks', CCS Research Report 643, College of Business Administration, The University of Texas at Austin, Austin, Texas, Oct 1989.

Compagnie, I., H. Gathon and P. Pestieau (1991), "Autonomy and Performance in Public Enterprises: the case of Railways and Postal Services", a paper presented at CIRIEC Seminar Public Versus Private Enterprises: In Search of the Real Issues, Liége, April 4-5, 1991.

Cubukgil, A. and R. Soberman (1984), "Costs of Rail Passenger Service in Canada: An Examination of Institutional Problems", Proceedings of 19th Annual Meeting, Canadian Transportation Research Forum, Jasper, Alberta, May 1984, 342-365.

Denny, M., M. Fuss and L. Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries with an Application to Canadian Telecommunications:, in T.G. Cowing and R.E. Stevenson, eds. Productivity Measurement in Regulated Industries, Academic Press.

Deprins, D. and L. Simar (1989), "Estimating Technical Inefficiencies with Correction for Environmental Conditions with an Application to Railway Companies", Annals of Public and Cooperative Economics, Vol. 60, No.1, 81-102.

Gathon, H. and S. Perelman (1990), "Measuring Technical Efficiency in European Railways: A Panel Data Approach", a paper presented at ORSA/TIMS joint national meeting, Philadelphia, Oct. 1990.

Greene, W.H. (1980), "Maximum Likelihood Estimation of Econometric Frontier Functions", Journal of Econometrics 13, 27-56.

Kim, M. and M. Spiegel (1987), "The Effect of Lump-sum Subsidies on the Structure of Production and Productivity in Regulated Industries," Journal of Public Economics 34, 105-119.

Kim, H. Y. (1987), "Economies of Scale and Scope in Multiproduct Firms: evidence from US Railroads", Applied Economics, 19, 733-741.

Maddala, G.S. (1983), Limited Dependent and Qualitative Variables in Econometrics, Cambridge University Press 1983.

Meeusen, W. and J. Van Den Broeck (1977) "Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error", International Economic Review, Vol.18, No.2, June 1977, 435-444.

Nash, C. (1981), "Government Policy and Rail Transport in Western Europe", Transport Review, Vol.1, No.3, 1981, 225-250.

Nash, C. (1985), European Railway Comparisons - What can we learn', International Railway Economics, ed. by K.J. Button and D.E. Pitfield, Gower Publishing, 1985.

Nash, C. (1991), "Rail Policy in the Europe Community", Institute for Transport Studies, The University of Leeds, Working Paper 324, Jan. 1991.

OECD (1988), National Accounts, Vol. 1, Department of Economics and Statistics, Paris 1988.

Perelman, S. and P. Pestieau (1988), "Technical Performance in Public Enterprises: A Comparative Study of Railway and Postal Services", European Economics Review, 32 (1988), 432-441.

Schnier, C., J. Jones and A. Pignal (1990), "Canadian Regional Railway Passenger Services: Was There Ever Any Potential for Financial Improvement", Proceedings of 25th Canadian Transportation Research Forum, Saskatoon, June 6-8, 1990, 254-267.

Simar, L. (1990), "Estimating Efficiencies from Frontier Models with Panel Data: a Comparison of Parametric, Non-Parametric and Semi-Parametric Methods", a paper presented at the ORSA/TIMS joint national meeting, Productivity and Global Competition, Philadelphia, Oct. 1990.

Stevenson, R.(1980), "Measuring Technological Bias", American Economic Review, Vol.70, No.1, March, 1980, 162-173.

Thompson, L.S., W. G. Wood and F. Lures (1991), "World Railway Performance Update", a special feature article in Railway Gazette: Year Book'91 (Developing Railways), 8-16.

Thoung, L. T.(1981), "International Comparison of Efficiency of Railroads in Relation to the Production and Cost Functions", International Journal of Transport Economics, Vol. VIII, No. December 1981, 327-338.

Tobin, J. (1958), "Estimation of Relationships for Limited Dependent Variables", Econometrica, 1958, 24-36.

UIC, International Railway Statistics, Paris, issues from 1978 to 1988.

VIA Rail Canada (1989), "Developments in Passenger Rail", supplementary volume 2, Review of Passenger Rail Transportation in Canada, September 1989.

APPENDIX

List of Sample Railways, Abbreviations, & Years Used

VIA:	VIA Rail Canada	1980-1988
AMTRAK:	The National Railroad Passenger Corp. (US)	1978-1988
AN:	Australian National Railways	1979-1988
BR :	British Railways (UK)	1978-1988
CFF:	Swiss Federal Railways (Switzerland)	1978-1988
CFL:	Luxembourg National Railway Company	1978-1988
CH:	Hellenic Railways Organization (Greece)	1978-1987
CIE:	Irish Transport Company	1978-1988
CP:	Portuguese Railways	1978-1988
DB:	Deutsche Bundesbahn-German Federal Railways	1978-1988
DSB:	Danish State Railways (Denmark)	1978-1988
FS:	Italian State Railways	1978-1988
JNR:	Japanese National Railways	1978-1986
KNR:	Korean National Railways	1979-1984
NS:	Netherlands Railways	1978-1988
NSB:	Norwegian State Railways	1978-1988
ÖBB:	Austrian Federal Railways	1978-1988
RENFE:	National System of Spanish Railways	1978-1988
SJ:	Swedish State Railways	1978-1988
SNCB:	Belgium National Railways	1978-1988
SNCF:	French National Railways	1978-1988
TCDD:	Turkish Republic State Railways	1978-1988
VR:	Finnish State Railways	1978-1988

Table 1

Gross Domestic Product per Capita
- at the Price Levels and Exchange Rates of 1985 (U.S. Dollars)

	1978	1980	1982	1984	1986	1988
Australia	8891	9304	9225	9748	10113	10620
Austria	7490	8088	8127	8422	8716	9195
Belgium	7334	7800	7832	8031	8209	8760
Canada	12143	12156	12287	13266	14143	15027
Denmark	9681	9939	10160	10888	11748	11639
Finland	8723	9799	10210	10174	11221	12232
France	8690	9005	9220	9350	9671	10125
W. Germany	9067	9535	9478	9966	10421	10919
Greece	3145	3245	3210	3275	3401	3508
Ireland	4711	4878	5038	5171	5264	5711
Italy	6339	6968	7029	7279	7628	8155
Japan	8669	9370	9869	10551	11183	12230
Korea	1576	1609	1786	2121	2507	3072
Luxembourg	8174	8389	8391	9177	9793	10545
Netherlands	8325	8470	8200	8508	8814	9001
Norway	11102	12075	12135	13346	14539	14696
Portugal	1967	2130	2178	2100	2217	2409
Spain	4166	4144	4120	4228	4429	4883
Sweden	10523	11062	11167	11808	12296	12851
Switzerland	12754	13562	13457	13752	14519	15017
Turkey	993	934	974	1016	1105	1182
UK	7323	7348	7372	7788	8339	9084
US	15176	15113	14748	16109	16921	17962

Source: OECD, National Accounts, Vol.1
International Financial Statistics

Table 2

Area, Population and Population Density (1987)

	Area Km	Population (000)	Population Density Persons/Km^2
Australia*	7682300*	16263	2.12
Austria	83850	7575	90.34
Belgium	30514	9868	323.39
Canada	92128418[1]	25652	2.78
China	9590000*	1080730	112.69
Denmark	42393*	5130	121.01
Finland	304623*	4932	16.19
France	551500	55627	100.86
W. Germany	248577	61149	246.00
Greece	131990	9998	75.75
Ireland	70283	3543	50.4
Italy	301268	57331	190.30
Japan	377719*	122264	323.69
S. Korea	99222	42082	424.1
Luxembourg	2586	372	143.9
Netherlands	40844	14671	359.20
Norway	30608*	4184	13.64
Portugal	92072	10350	112.4
Spain	504782	38830	76.92
Sweden	410928*	8399	20.44
Switzerland	41293	6619	160.29
Turkey	779452	50664*	65.0*
U.K.**	240882*	56930	236.34
U.S.	9372614	243915	26.02

*: 1985
**: Land area
1: Total area is 9970610 km^2, of which 7.6% is lakes and rivers.

Sources: OECD, National Accounts, Vol.I;
Source:

Korea Annual 1989;
Statistical Yearbook for Asia and the Pacific 1986-87;
Year Book Australia;
Annual Abstract of Statistics (UK);
Statistical Yearbook of Finland;
Statistical Handbook of Japan;
China Statistical Abstract;
Yearbook of Nordic Statistics
Canada Yearbook
Statistical Yearbook of Norway
Statistical Yearbook of Greece
Europa World Year Book

Table 3

Rail's Share in Passenger Market

(percentage in passenger kilometres*)

	1980	1985	1986	1987
Canada**	–	2.4% (1984)	1.9%	1.6% (1988)
US**	0.7	0.6	0.7	0.7
Austria	9.9	9.4	9.4	9.4
Belgium	9.7	8.2	7.6	7.6
Denmark	7.4	7.8	7.5	7.4
Finland	7.0	6.2	5.1	5.8
France	9.8	10.3	9.5	9.2
Germany	6.6	7.4	6.8	6.3
Great Britain	7.0	7.0	7.0	7.0
Greece	8.9	9.7	9.7	9.7
Ireland	n/a	n/a	n/a	n/a
Italy	8.3	7.8	7.9	7.2
Japan	40.2	38.9	38.1	37.1
S. Korea	n/a	21.1	20.9	21.1
Luxembourg	n/a	n/a	n/a	n/a
Netherlands	6.2	6.0	5.6	5.8
Norway	6.6	5.1	4.8	4.5
Portugal	10.9	8.4	8.8	7.9
Spain	7.7	9.2	9.4	8.5
Sweden	8.4	7.2	6.5	6.2
Switzerland	12.7	12.2	12.6	12.6
Turkey	n/a	n/a	n/a	n/a

* Rail passenger traffic includes suburban traffic carried by railways, but excludes urban traffic carried by metro systems. Total passenger traffic includes those carried by cars, buses, and rail, and domestic air modes.

** The Rail's share for Canada and the U.S. are computed only for intercity passengers.

Sources: Royal Commission on National Passenger Transportation (Canada), Transportation Data, Research Division, (Feb. 1991, p10).
ECMT, Statistical Trends in Transport , various issues
Transport Statistics Great Britain 1978-88
Statistical Yearbook of Japan, 1988
Railroad Facts (US), 1988
BTCE (1988)
ICAO, Digest of Statistics, various issues
International Road Federation (IRF), World Road Statistics, various issues

Table 4

LENGTH OF ROUTES IN KILOMETRES

	1978	1980	1982	1984	1986	1988
VIA (Canada)	-	18500	18300	18600	18500	18500
Amtrak (US)	41834	38616	37007	38616	38616	38616
AN (Australia)	7890	7687	7638	7450	7450	7450
BR (UK)	17901	17745	17230	16803	16670	16599
CFF-SBB (Switzerland)	2934	2943	2956	2984	2986	2990
CFL (Luxembourg)	270	270	270	270	270	272
CH (Greece)	2461	2461	2461	2461	2461	2479
CIE (Ireland)	2007	1987	1987	1944	1944	1944
CP (Portugal)	3588	3609	3616	3613	3603	3608
DB (Germany)	28539	28497	28270	27799	27490	27284
DSB (DENMARK)	2004	2015	2015	2448	2471	2476
FS (Italy)	16391	16480	16473	16420	16068	16015
JNR (Japan)	21307	21322	21386	21091	19949	19237
KNR (Korea)	3158	3135	3121	3120	3113	3150
NS (Netherlands)	2876	2880	2850	2852	2817	2828
NSB (NORWAY)	4241	4242	4242	4242	4216	4175
ÖBB (AUSTRIA)	5857	5857	5854	5797	5745	5630
RENFE (Spain)	13418	13431	13461	13466	12721	12550
SJ (Sweden)	11377	11377	11750	11485	11236	11076
SNCB (BELGIUM)	4302	4266	4240	4194	3618	3554
SNCF (France)	34522	34362	34599	34688	34441	34563
TCDD (Turkey)	7935	8193	8156	8169	8170	8164
VR (FINLAND)	6057	7075	6069	5979	5899	5884

Sources: Amtrak, Annual Report, various years
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 5

PASSENGER KILOMETRES (MILLION)

	1978	1980	1982	1984	1986	1988
VIA (Canada)	–	3103	2538	2468	2261	2298
Amtrak (US)	6483	7372	6713	7324	8066	9136
AN (Australia)	490	249	276	238	214	235
BR (UK)	30740	31704	27360	29700	30819	34315
CFF-SBB (Switzerland)	8083	9167	8956	9032	9325	10804
CFL (Luxembourg)	239	246	251	231	224	223
CH (Greece)	1568	1464	1501	1652	1950	1963
CIE (Ireland)	966	1032	887	903	1075	1180
CP (Portugal)	5512	6077	5414	5456	5803	6036
DB (Germany)	37589	40499	40030	39075	41397	40959
DSB (DENMARK)	3128	3353	4215	4421	4536	4797
FS (Italy)	39211	39587	40019	37127	40500	43343
JNR (Japan)	195844	193143	190767	194180	198299	204679
KNR (Korea)	n/a	21640	21033	21884	23563	25978
NS (Netherlands)	8146	8910	9376	8997	8919	9664
NSB (NORWAY)	2058	2394	2242	2198	2225	2110
ÖBB (AUSTRIA)	7109	7380	7217	7004	7332	7783
RENFE (Spain)	16758	13527	14703	15574	15646	15716
SJ (Sweden)	5369	6787	6381	6483	6152	6081
SNCB (BELGIUM)	7136	6963	6879	6444	6069	6348
SNCF (France)	53263	54251	56605	59953	59618	63057
TCDD (Turkey)	5600	6011	5440	6277	6052	6708
VR (FINLAND)	2983	3216	3326	3276	2676	3201

Sources: Amtrak, Annual Report, various years
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 6

AVERAGE LENGTH OF TRIPS (kilometres)

	1978	1980	1982	1984	1986	1988
VIA (Canada)	–	409	351	355	360	358
Amtrak (US)	343	348	353	368	397	425
AN(Australia)	–	488	640	666	n/a	n/a
BR (UK)	42	42	43	43	45	45
CFF-SBB (Switzerland)	40	42	41	41	41	42
CFL(Luxembourg)	22	22	21	21	21	21
CH(Greece)	147	144	148	150	166	–
CIE(Ireland)	61	62	69	58	50	49
CP(Portugal)	27	27	26	25	26	26
DB (Germany)	38	37	37	37	41	42
DSB (DENMARK)	35	26	31	33	31	33
FS (Italy)	101	104	103	90	102	106
JNR (Japan)	28	28	28	28	28	28
KNR(Korea)	n/a	50	47	45	–	–
NS (Netherlands)	46	45	45	44	42	42
NSB (NORWAY)	60	63	60	63	63	62
ÖBB (AUSTRIA)	42	43	42	44	46	49
RENFE (Spain)	81	81	81	81	81	81
SJ (Sweden)	82	88	85	84	84	82
SNCB (BELGIUM)	42	42	42	43	44	44
SNCF (France)	79	80	80	80	78	79
TCDD(Turkey)	48	53	45	48	47	49
VR (FINLAND)	80	82	80	80	77	73

Sources: Amtrak, Annual Report, various years
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 7

Train Kilometres (000)

	1978	1980	1982	1984	1986	1988
VIA Rail (Canada)						
Passenger	–	24439	19940	19649	20984	20106
Amtrak (US)						
Passenger	52083	47353	46114	46613	46024	48270
AN (Australia)						
Passenger	3496	2924	2992	1789	2486	2439
Freight	9656	9364	9098	8450	10482	8315
BR (UK)						
Passenger	330023	342591	300612	403937a	326472	357548
Freight	99762	87682	70680	80249a	67961	67597
CFF (Switzerland)						
Passenger	64687	66932	74057	79515	80356	90732
Freight	28675	28990	27649	26790	25530	26826
CH (Greece)						
Passenger	13280	12087	13245	13669	13770	n/a
Freight	3474	2855	2660	2865	2801	n/a
CIE (Ireland)						
Passenger	8323	8467	7805	8415	9655	9288
Freight	4676	4966	4384	4211	4239	3942
CFL (Luxembourg)						
Passenger	2834	2822	2914	2884	3218	3074
Freight	1498	1528	1267	1303	1900	1299
CP (Portugal)						
Passenger	25174	28218	30076	30281	31113	32054
Freight	5936	6553	6677	7333	7257	8498

Table 7 cont.

Train Kilometres (000)

	1978	1980	1982	1984	1986	1988
DB (Germany)						
Passenger	381852	401452	390704	382253	387890	392270
Freight	193073	204554	190511	196761	201841	194777
DSB (Denmark)						
Passenger	37547	39280	41330	41350	41175	41610
Freight	7109	8890	8800	8800	8800	8405
FS (Italy)						
Passenger	225435	229206	230227	234898	235784	236002
Freight	56520	57456	55456	56728	56737	63165
JNR (Japan)						
Passenger	517744	518152	515531	515522	551993	571081b
Freight	159337	141688	127337	101780	85091	75490b
KNR (Korea)						
Passenger	n/a	43293	47631	50782	56862	59118
Freight	n/a	22026	21560	24587	25735	27969
NS (Netherlands)						
Passenger	94088	95999	100292	101461	101985	106078
Freight[c]	13702	14468	13621	12787	12160	11649

Table 7 cont.

Train Kilometres (000)

	1978	1980	1982	1984	1986	1988
NSB (Norway)						
Passenger	22892	23274	23544	22752	22688	22065
Freight	11130	11458	10662	10100	10753	9192
ÖBB (Austria)						
Passenger	57884	60244	62756	63824	64967	66868
Freight	34497	37613	36223	36146	36547	36431
RENFE (Spain)						
Passenger	92781	94685	103191	104132	105741	109995
Freight	43546	42311	40899	46606	50402	48959
SJ (Sweden)						
Passenger	59133	60029	62882	65288	62563	60919
Freight	39174	39412	38194	40566	41128	40791
SNCB (Belgium)						
Passenger	69069	72028	73374	72561	70497	71422
Freight	21777	23115	21094	21737	21184	20817
SNCF (France)						
Passenger	283238	290477	300259	306898	295112	309026
Freight	208696	214599	196692	183777	168528	169366
TCDD (Turkey)						
Passenger	19703	21529	21255	24980	26177	26104
Freight	17812	13944	17189	19395	19155	17434
VR (Finland)						
Passenger	25684	25607	25050	24425	21823	23875
Freight	15804	19327	19443	18897	16505	18157

Note a: From Jan. 1984 - Mar. 1985
b: Collected results of the seven railway companies that have replaced JNR.
c: All non-passenger train km

Sources: UIC, International Railway Statistics
AN, Annual reports
Amtrak, Annual reports
VIA, Annual reports
US, National Transportation Statistics

Table 8

PERCENTAGE OF ELECTRIFIED ROUTE KMS

	1978	1980	1982	1984	1986	1988
VIA (Canada)	–	0	0	0	0	0
Amtrak (US)	2.7%	2.9%	3.0%	2.9%	2.9%	2.9%
AN (Australia)	0	0	0	0	0	0
BR (UK)	21	21	22	23	25	26
CFF-SBB (Switzerland)	99	99	99	99	99	99
CFL (Luxembourg)	51	53	60	60	60	60
CH (Greece)	0	0	0	0	0	0
CIE (Ireland)	0	0	0	2	2	2
CP(Portugal)	12	12	13	13	13	13
DB (Germany)	37	39	40	41	42	43
DSB (DENMARK)	6	7	7	6	8	9
FS (Italy)	51	53	53	54	56	58
JNR (Japan)	38	39	41	43	47	–
KNR (Korea)	n/a	14	14	14	14	14
NS (Netherlands)	61	61	63	63	65	69
NSB (NORWAY)	58	58	58	58	58	58
ÖBB (AUSTRIA)	50	51	52	54	54	57
RENFE (Spain)	36	41	46	46	49	50
SJ (Sweden)	62	62	60	62	62	63
SNCB (BELGIUM)	30	33	42	45	60	64
SNCF (France)	28	29	31	32	33	35
TCDD (Turkey)	3	3	3	4	4	4
VR (FINLAND)	11	15	17	24	24	28

Sources: Amtrak, Annual Report, various years
AN, Annual Reports, 1987-88
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 9

Operating Revenue*/operating costs

	1978	1980	1982	1984	1986	1988
VIA(Canada)	–	0.31	0.30	0.34	0.30	0.28
Amtrak (US)	0.35	0.39	0.47	0.51	0.56	0.63
AN (Australia)	0.62	0.71	0.73	0.70	0.80	0.86
BR (UK)	0.78	0.74	0.61	0.61	0.74	0.92
CFF (Swiss)**	0.73	0.74	0.69	0.76	0.76	0.73
CFL (Luxembourg)	0.33	0.31	0.26	0.26	0.24	0.23
CH (Greece)	0.56	0.54	0.42	0.40	0.34	0.28
CIE(Ireland)	0.77	0.68	0.64	0.67	0.72	0.76
CP(Portugal)	0.44	0.46	0.45	0.53	0.44	0.50
CR (China)	n/a	1.62	1.68	1.93	1.72	1.52
DB (Germany)	0.54	0.58	0.57	0.59	0.59	0.59
DSB (Denmark)	0.70	0.68	0.61	0.63	0.65	0.63
FS (Italy)	0.32	0.29	0.21	0.23	0.23	0.22
JNR (Japan)	0.62	0.70	0.62	0.60	0.59	1.12
KNR (Korea)	n/a	0.84	0.83	0.88	0.96	0.96
NS (Netherlands)	0.53	0.56	0.54	0.54	0.54	0.57
NSB (Norway)	0.72	0.72	0.70	0.68	0.63	0.60
ÖBB (Austria)	0.67	0.67	0.66	0.65	0.61	0.63
PK (Pakistan)	1.35	1.25	1.06	1.01	1.09	1.16
RENFE (Spain)	0.68	0.55	0.47	0.34	0.40	0.46
SJ (Sweden)	0.82	0.83	0.83	0.83	0.84	0.81
SNCB (Belgium)*	0.40	0.44	0.43	0.43	0.44	0.43
SNCF (France)	0.63	0.66	0.60	0.58	0.61	0.65
TCDD (Turkey)	0.52	0.45	0.75	0.70	0.76	0.73
VR (Finland)	0.74	0.77	0.72	0.74	0.69	0.74

*. "Operating revenues" do not include payments from government, and "operating costs" include depreciation and amortization, but exclude interest or return on capital invested.

**. The Government has been paying the infrastructure costs of CFF since 1987, on the other hand CFF pays the government a contribution towards the infrastructure expenses. To be consistent with the earlier data, government payment for infrastructure and CFF's contribution towards infrastructure expenditure are excluded in calculating the financial ratios.

Sources: Amtrak, Annual Reports
AN, Annual Reports
China, Railways of China
UIC, International Railway Statistics
US, National Transportation Statistics
VIA, Annual Reports

Table 10
DIRECT SUBSIDY/OPERATING COSTS

	1978	1980	1982	1984	1986	1988
VIA (Canada)	--	0.697	0.716	0.667	0.671	0.715
Amtrak (US)	0.782	0.712	0.504	0.478	0.435	0.308
AN (Australia)	0.327	0.261	0.254	0.274	0.206	0.154
BR (UK)	0.224	0.236	0.327	0.309	0.238	0.172
CFF (Switzerland)*	n/a	0.082	0.168	0.163	0.155	0.119
CFL(Luxembourg)	0.666	0.662	0.735	0.738	0.753	0.750
CH(Greece)	0.446	0.468	0.594	0.615	0.667	0.721
CIE(Ireland)	0.241	0.310	0.314	0.305	0.298	0.256
CP(Portugal)	0.628	0.453	0.248	0.384	0.432	0.289
DB (Germany)	0.290	0.301	0.299	0.311	0.304	0.292
DSB (Denmark)	--	0.316	0.388	0.373	0.350	0.373
FS (Italy)	0.328	0.446	0.621	0.600	0.654	0.661
JNR (Japan)	0.064	0.073	0.076	0.055	0.043	0.005
KNR(Korea)	n/a	0.015	0.069	0.095	0.048	0.048
NS (Netherlands)	0.469	0.427	0.449	0.470	0.460	0.474
NSB (Norway)	0.285	0.280	0.302	0.323	0.367	0.397
ÖBB (Austria)	0.136	0.136	0.134	0.159	0.222	0.409
RENFE (Spain)	--	0.453	--	n/a	0.476	0.498
SJ (Sweden)	0.151	0.132	0.126	0.166	0.139	0.152
SNCB (Belgium)*	0.598	0.553	0.517	0.563	0.531	0.563
SNCF (France)	0.303	0.296	0.283	0.318	0.292	0.283
TCDD (Turkey)	0.285	0.407	0.349	0.396	0.136	0.134
VR (Finland)	--	0.023	0.021	0.021	0.024	0.026

Sources:

Amtrak, Annual Reports
AN, Annual Reports
UIC, International Railway Statistics
US, National Transportation Statistics
VIA, Annual Reports

* See notes at the end of Table 9

Table 11

TRAFFIC DENSITY

(Passenger Km per Route Km ,000)

	1978	1980	1982	1984	1986	1988
VIA (Canada)	-	168	139	132	122	124
Amtrak (US)	167	205	207	177	201	217
AN (Australia)[1]	47	32	36	32	28	32
BR (UK)	2139	2208	1916	2084	2155	2398
CFF-SBB (Switzerland)	2781	3145	3061	3068	3188	3682
CFL (Luxembourg)	1048	1091	1077	996	952	944
CH (Greece)	638	593	610	670	792	n/a
CIE (Ireland)	588	649	541	547	650	714
CP (Portugal)	1535	1685	1496	1511	1610	1674
DB (Germany)	1595	1734	1773	1796	1969	1954
DSB (DENMARK)	1574	1678	2110	2212	2154	2272
FS (Italy)	2478	2477	2509	2327	2604	2783
JNR (Japan)	8711	8585	8163	8405	9030	9657[2]
KNR (Korea)	n/a	7127	6940	7243	-	-
NS (Netherlands)	3257	3557	3686	3541	3474	3776
NSB (NORWAY)	502	584	547	536	546	519
ÖBB (AUSTRIA)	1258	1305	1276	1251	1357	1528
RENFE (Spain)	1249	1007	1092	1157	1381	1410
SJ (Sweden)	498	630	601	624	652	648
SNCB (BELGIUM)	2232	2147	2106	1929	2128	2268
SNCF (France)	2174	2243	2383	2510	2495	2651
TCDD (Turkey)	706	733	666	769	740	822
VR (FINLAND)	647	689	733	743	594	721

1. Since AN does not regularly report passenger kilometres, the 1986 and 1988 figures are estimated using the 1984 number under the assumption that its average distance of trips remain unchanged.
2. JNR's number is for 1987.

Sources: Amtrak, Annual Report, various years
AN, Annual Reports, 1987-88
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 12

LABOUR PRODUCTIVITY
(Passenger Kms per Employee ,000)

	1978	1980	1982	1984	1986	1988
VIA (Canada)	-	306	271	288	266	283
Amtrak (US)	248	278	272	295	343	392
AN (Australia)	-	80	91	116	106	117
BR (UK)	176	177	164	240	222	272
CFF-SBB (Switzerland)	293	328	304	299	315	357
CFL(luxembourg)	87	90	88	87	92	86
CH(Greece)	148	144	134	148	187	n/a
CIE (Ireland)	176	195	173	184	225	260
CP (Portugal)	243	291	271	291	333	341
DB (Germany)	152	175	177	189	219	232
DSB (DENMARK)	201	215	258	277	340	360
FS (Italy)	215	217	216	202	226	245
JNR (Japan)	613	610	632	740	1057	-
KNR(Korea)	n/a	776	724	793		
NS (Netherlands)	346	368	373	369	352	393
NSB (NORWAY)	171	205	190	200	214	197
ÖBB (AUSTRIA)	147	155	148	146	153	168
RENFE (Spain)	331	269	272	295	319	395
SJ (Sweden)	240	307	282	296	303	328
SNCB (BELGIUM)	158	141	145	150	154	174
SNCF (France)	324	342	344	360	373	432
TCDD(Turkey)	147	196	166	205	203	189
VR (FINLAND)	182	204	212	221	177	233

Sources: Amtrak, Annual Report, various years
AN, Annual Reports, 1987-88
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 13

CAPITAL PRODUCTIVITY
(Passenger Kms per Passenger Car, million)

	1978	1980	1982	1984	1986	1988
VIA	-	3.0	3.4	3.4	3.0	3.2
Amtrak (US)	3.1	3.6	3.4	4.1	4.4	4.9
AN (Australia)	–	0.9	1.2	1.1	0.9	1.0
BR (UK)	1.8	1.9	1.8	2.1	2.2	2.7
CFF-SBB (Switzerland)	2.1	2.3	2.2	2.2	2.4	2.7
CFL(Luxembourg)	2.4	2.5	2.4	2.2	2.0	2.0
CH (Greece)	2.4	2.2	2.2	2.5	2.8	n/a
CIE(Ireland)	2.7	3.0	2.7	2.8	3.3	3.5
CP(Portugal)	4.9	5.3	4.5	4.5	4.7	4.9
DB (Germany)	2.0	2.2	2.3	2.3	2.6	2.7
DSB (DENMARK)	1.9	2.1	2.5	2.7	2.8	3.0
FS (Italy)	2.9	2.9	2.9	2.5	2.8	3.1
JNR (Japan)	7.4	7.1	7.1	7.7	8.2	–
KNR(Korea)	n/a	9.5	8.0	8.4	–	–
NS (Netherlands)	4.2	4.5	4.4	4.3	4.1	4.4
NSB (NORWAY)	2.2	2.6	2.5	2.4	2.3	2.3
ÖBB (AUSTRIA)	1.8	1.8	1.9	1.9	1.9	2.0
RENFE (Spain)	4.7	3.9	3.8	4.0	3.9	4.1
SJ (Sweden)	2.7	3.4	3.1	3.2	3.1	3.2
SNCB (BELGIUM)	2.1	1.9	1.9	1.7	1.7	1.9
SNCF (France)	3.3	3.4	3.6	3.8	3.8	4.1
TCDD (TUrkey)	4.4	4.4	3.9	4.5	4.1	5.0
VR (FINLAND)	2.7	2.9	3.0	3.1	2.5	3.1

Sources: Amtrak, Annual Report, various years
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 14

ENERGY PRODUCTIVITY
(Passenger Kms per Million BTU)

	1978	1980	1982	1984	1986	1988
VIA (Canada)	–	524	547	724	450	536
Amtrak (US)	499	696	685	696	847	789
AN (Australia)	–	581	518	522	339	296
BR (UK)	1043	1054	1048	1051	1092	1200
CFF-SBB (Switzerland)	2207	2316	2174	2100	2085	2156
CFL(Luxembourg)	774	735	806	767	786	710
CH(Greece)	1189	1177	1087	1093	1345	n/a
CIE(Ireland)	1010	1177	1087	1093	1345	1357
CP(Portugal)	2539	2739	2383	2437	2500	2486
DB (Germany)	1331	1332	1402	1424	1507	1489
DSB (DENMARK)	832	889	1005	1130	1048	1191
FS (Italy)	2721	2974	3071	2702	2878	3018
JNR (Japan)	4679	4606	4665	5128	5244	–
KNR(Korea)	n/a	3329	2949	2823	–	–
NS (Netherlands)	2173	2228	2350	2239	2155	2241
NSB (NORWAY)	1648	1797	1750	1679	1552	1310
ÖBB (AUSTRIA)	1709	1615	1583	1486	1533	1604
RENFE (Spain)	2241	2851	1951	2098	2076	1982
SJ (Sweden)	1584	1820	1657	1558	1507	1494
SNCB (BELGIUM)	1144	1067	1110	1075	1139	1148
SNCF (France)	2431	2472	2570	2627	2715	2743
TCDD(Turkey)	687	663	635	747	970	1192
VR (FINLAND)	1197	1298	1429	1477	1360	1495

Sources: Amtrak, Annual Report, various years
AN, Annual Reports, 1987-88
VIA, Annual Report, various years
UIC, International Railway Statistics, various issues

Table 15

DEA GROSS EFFICIENCY INDEX

	1978	1980	1982	1984	1986	1988	Average 85-88
VIA (Canada)	-	0.76	0.69	0.72	0.66	0.70	0.68
Amtrak (US)	0.63	0.80	0.79	0.84	0.92	1.00	0.94
AN (Australia)	-	0.21	0.25	0.27	0.24	0.27	0.24
BR (UK)	0.57	0.60	0.55	0.76	0.77	1.00	0.82
CFF-SBB (Switzerland)	0.87	0.94	0.89	0.87	0.88	0.98	0.93
CFL(Luxembourg)	0.48	0.50	0.48	0.44	0.41	0.41	0.42
CH(Greece)	0.46	0.44	0.42	0.46	0.54	-	0.52
CIE(Ireland)	0.51	0.56	0.51	0.53	0.63	0.71	0.66
CP(Portugal)	0.93	1.00	0.88	0.92	0.98	1.00	0.99
DB (Germany)	0.51	0.53	0.55	0.56	0.61	0.62	0.61
DSB (DENMARK)	0.49	0.53	0.64	0.68	0.79	0.86	0.81
FS (Italy)	0.91	0.97	0.99	0.88	0.95	0.99	0.97
JNR (Japan)	-	-	-	-	-	-	
KNR (Korea)	-	-	-	-	-	-	
NS (Netherlands)	0.94	1.00	1.00	0.97	0.94	1.00	0.97
NSB (NORWAY)	0.58	0.64	0.62	0.60	0.56	0.51	0.56
ÖBB (AUSTRIA)	0.57	0.56	0.54	0.52	0.54	0.57	0.54
RENFE (Spain)	1.00	0.80	0.82	0.89	0.91	0.96	0.93
SJ (Sweden)	0.61	0.76	0.70	0.72	0.72	0.76	0.74
SNCB (BELGIUM)	0.59	0.57	0.56	0.51	0.56	0.60	0.59
SNCF (France)	0.88	0.90	0.92	0.96	0.98	1.00	0.98
TCDD(Turkey)	0.82	0.83	0.73	0.83	0.77	0.93	0.83
VR (FINLAND)	0.52	0.57	0.59	0.61	0.52	0.63	0.58

Table 16

Definition of Variables Used in Regression Analysis

Variables	Description
	UNCONTROLLABLE FACTORS
LEFF	log (DEA efficiency index)
SHARE	Rail's share in passenger transport market (in terms of passenger Km)
DENSITY	Traffic Density measured by passenger Kms per route Km
%PASSENGER	Percentage of passenger train-Km in total train-Km
TRIP LENGTH	Average length of passenger trip (Km)
TIME	Time Trend
	CONTROLLABLE FACTORS
SUBSIDY/C	Percentage of subsidy to total operating costs
%ELECTRIC	Percentage of Electrified Route Miles
AUTONOMY	Extent of managerial freedom
QUASI PUB	A Dummy variable = 1 if the railway is a quasi-public corporation (VIA and AMTRAK)
GOV AGENCY	A Dummy variable = 1 if the railway is run by a government agency
PASS ONLY	A Dummy Variable = 1 if the railway is a single national passenger-only organization
DEFICIT	A Dummy Variable = 1 if subsidy covers 100 percent of deficit

Table 17

Partial Factor Productivity Regressions

(t-ratios in parentheses)

	Productivity		
Variables	Labour	Energy	Rolling Stock
DENSITY	0.454 (14.78)	0.485 (16.36)	0.308 (9.28)
TRIP LENGTH	0.285 (6.25)	0.385 (8.77)	-0.001 (0.18)
%ELECTRIC	-0.006 (0.63)	0.041 (4.28)	-0.027 (2.55)
SUBSIDY/C	-0.071 (4.72)	-0.021 (1.48)	-0.039 (2.43)
GOV.AGENCY	-0.114 (1.83)	-0.183 (3.04)	-0.152 (2.27)
PASS.ONLY	0.684 (7.30)	-0.430 (4.75)	0.772 (7.63)
INTERCEPT	1.964 (6.71)	3.490 (12.37)	-0.492 (1.56)
No.Observation	242	242	242
D.F.	235	235	235
Log-likelihood	-58.54	-49.84	-77.10
R^2	0.5971	0.7244	0.4310

N.B. Productivity measures and all variables except GOVERNMENT AGENCY and PASSENGER-ONLY dummies are in logarithms.

Table 18

Tobit Regression Results

Dependent Variable : LEFF= LOG(DEA gross efficiency indices)

	Model 1		Model 2	
Variables	Coefficients	t-values	Coefficients	t-value
DENSITY	0.22	6.34	0.28	7.33
TRIP LENGTH	0.12	3.68	0.14	4.38
%PASSENGER	0.25	2.76	0.11	1.06
%ELECTRIC	0.03	3.27	0.02	3.17
SUBSIDY/C	-0.02	1.35	-0.0002	0.02
AUTONOMY	0.27	3.63		
GOV. AGENCY			-0.19	4.33
QUASI-PUB.			0.04	0.50
PASS ONLY	0.94	6.78	0.68	5.64
CONSTANT	-2.92	8.73	-2.19	8.09
No. of Observation:		227	227	
LOG-LIKEHOOD FUNCTION:		37.817	41.140	
R^2		0.6414	0.6507	

* Efficiency index and all the variables are in natural logarithms except for the dummy variables.

Table 19

MANAGERIAL (NET) EFFICIENCY INDEX

	1978	1980	1982	1984	1986	1988	Average 85-88
VIA (Canada)	-	0.58	0.57	0.60	0.56	0.59	0.57
Amtrak (US)	0.47	0.57	0.56	0.59	0.62	0.66	0.63
AN (Australia)	-	0.48	0.52	0.60	0.56	0.58	0.55
BR (UK)	0.43	0.44	0.42	0.54	0.56	0.71	0.59
CFF-SBB (Switzerland)	0.59	0.62	0.59	0.58	0.58	0.62	0.60
CFL(Luxembourg)	0.46	0.48	0.46	0.43	0.42	0.42	0.42
CH(Greece)	0.48	0.47	0.44	0.47	0.51	-	0.50
CIE(Ireland)	0.62	0.67	0.62	0.58	0.67	0.74	0.70
CP(Portugal)	0.80	0.84	0.77	0.80	0.84	0.85	0.85
DB (Germany)	0.50	0.51	0.53	0.53	0.55	0.57	0.56
DSB (DENMARK)	0.50	0.54	0.60	0.63	0.62	0.65	0.58
FS (Italy)	0.68	0.72	0.73	0.68	0.60	0.62	0.61
JNR (Japan)	-	-	-	-	-	-	-
KNR(Korea)	-	-	-	-	-	-	-
NS (Netherlands)	0.61	0.64	0.64	0.62	0.60	0.64	0.62
NSB (NORWAY)	0.59	0.63	0.62	0.60	0.56	0.51	0.56
ÖBB (AUSTRIA)	0.49	0.47	0.46	0.44	0.44	0.45	0.44
RENFE (Spain)	0.78	0.66	0.66	0.70	0.69	0.74	0.70
SJ (Sweden)	0.60	0.70	0.66	0.68	0.67	0.71	0.69
SNCB (BELGIUM)	0.43	0.42	0.41	0.38	0.41	0.43	0.42
SNCF (France)	0.59	0.60	0.61	0.64	0.65	0.66	0.66
TCDD(Turkey)	0.87	0.85	0.80	0.86	0.80	0.93	0.85
VR (FINLAND)	0.50	0.54	0.55	0.57	0.51	0.59	0.55

Table 19 (b)

MANAGERIAL (NET) EFFICIENCY INDEX

	1978	1980	1982	1984	1986	1988	Average 85-88
VIA (Canada)	-	0.57	0.54	0.59	0.53	0.58	0.55
Amtrak (US)	0.47	0.57	0.55	0.56	0.59	0.64	0.60
AN (Australia)	-	0.44	0.47	0.58	0.53	0.54	0.51
BR (UK)	0.40	0.41	0.39	0.51	0.53	0.66	0.55
CFF-SBB (Switzerland)	0.59	0.61	0.58	0.56	0.56	0.58	0.57
CFL(Luxembourg)	0.46	0.47	0.45	0.42	0.41	0.42	0.41
CH(Greece)	0.49	0.48	0.45	0.48	0.53	-	0.52
CIE(Ireland)	0.59	0.64	0.59	0.54	0.63	0.69	0.65
CP(Portugal)	0.77	0.81	0.72	0.77	0.80	0.81	0.81
DB (Germany)	0.41	0.42	0.44	0.44	0.46	0.47	0.46
DSB (DENMARK)	0.43	0.48	0.54	0.57	0.67	0.70	0.67
FS (Italy)	0.57	0.61	0.63	0.57	0.60	0.62	0.61
JNR (Japan)	-	-	-	-	-	-	-
KNR(Korea)	-	-	-	-	-	-	-
NS (Netherlands)	0.59	0.62	0.62	0.60	0.58	0.62	0.60
NSB (NORWAY)	0.61	0.65	0.64	0.61	0.57	0.52	0.57
ÖBB (AUSTRIA)	0.53	0.51	0.50	0.47	0.48	0.50	0.49
RENFE (Spain)	0.81	0.68	0.68	0.73	0.72	0.71	0.73
SJ (Sweden)	0.53	0.63	0.58	0.60	0.60	0.63	0.61
SNCB (BELGIUM)	0.43	0.41	0.40	0.37	0.40	0.42	0.41
SNCF (France)	0.61	0.63	0.63	0.64	0.65	0.66	0.65
TCDD(Turkey)	0.87	0.84	0.79	0.85	0.77	0.90	0.83
VR (FINLAND)	0.48	0.50	0.59	0.60	0.54	0.63	0.59

With Autonomy Index

Table 20

Production Function Regression Results

Dependent Variable : LPAKM=LOG(Passenger Kilometres)

	Model 1		Model 2	
Variables	Coefficients	t-values	Coefficients	t-value
PASSENGER CAR	0.43	5.56	0.44	6.09
LABOUR	0.05	0.66	0.03	0.44
ENERGY	0.26	4.15	0.27	4.62
ELECTRIFIED LINE	0.03	4.38	0.03	4.64
NON-ELECT. LINE	0.14	7.76	0.15	8.80
DENSITY	0.57	14.30	0.59	17.35
TRIP LENGTH	0.27	5.54	0.26	5.91
%PASSENGER	0.07	0.71		
SUBSIDY/C	-0.05	3.75	-0.05	3.95
AUTONOMY	0.04	0.50		
GOV. AGENCY			-0.18	3.93
PASS ONLY	0.39	2.64	0.28	3.01
CONSTANT	-2.27	5.06	-4.49	15.69
No. of Observation:	242		242	
Degree of freedom:	230		231	
LOG-LIKEHOOD FUNCTION:	11.249		18.761	
R^2	0.9782		0.9795	

* All variables except for the dummy variables are in natural logarithms.

Table 21

EFFICIENCY INDEX COMPARISON[a]

Railways	Countries	DEA-TOBIT	PRODUCTION FUNCTION
VIA	Canada	0.57	0.56
Amtrak	US	0.63	0.63
AN	Australia	0.55	0.56
BR	UK	0.59	0.53
CFF-SBB	Switzerland	0.60	0.74
CFL	Luxembourg	0.42	0.44
CH	Greece	0.50b	0.58b
CIE	Ireland	0.70	0.68
CP	Portugal	0.85	0.98
DB	Germany	0.56	0.64
DSB	Denmark	0.58	0.56
FS	Italy	0.61	0.50
JNR	Japan	–	–
KNR	Korea	–	–
NS	Netherlands	0.62	0.64
NSB	Norway	0.56	0.65
ÖBB	Austria	0.44	0.51
RENFE	Spain	0.70	0.73
SJ	Sweden	0.69	0.60
SNCB	Belgium	0.42	0.39
SNCF	France	0.66	0.62
TCDD	Turkey	0.85	0.69
VR	Finland	0.55	0.53

a: average of 1985-88
b: average of 1985-87

Table 21 (b)

EFFICIENCY INDEX COMPARISON[a]

Railways	Countries	DEA-TOBIT	PRODUCTION FUNCTION
VIA	Canada	0.55	0.59
Amtrak	US	0.60	0.60
AN	Australia	0.51	0.54
BR	UK	0.55	0.53
CFF-SBB	Switzerlands	0.57	0.71
CFL	Luxembourg	0.41	0.44
CH	Greece	0.52b	0.61b
CIE	Ireland	0.65	0.65
CP	Portugal	0.81	0.97
DB	Germany	0.46	0.59
DSB	Denmark	0.67	0.57
FS	Italy	0.61	0.54
JNR	Japan	-	-
KNR	Korea	-	-
NS	Netherlands	0.60	0.63
NSB	Norway	0.57	0.67
ÖBB	Austria	0.49	0.59
RENFE	Spain	0.73	0.79
SJ	Sweden	0.61	0.58
SNCB	Belgium	0.41	0.40
SNCF	France	0.65	0.68
TCDD	Turkey	0.83	0.74
VR	Finland	0.59	0.58

a: average of 1985-88
b: average of 1985-87

With Autonomy Index